THE GEORGIA TECH RADIO METEOR WIND FACILITY

by

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INTRODUCTION

The Georgia Tech Radio Meteor Wind Facility was originally conceived in 1970 as a single receiving station, continuous wave system, with adequate sensitivity to record 1000 useful echoes per day, and range and echo arrival angle accuracy such that the height of each echo was specified to $\pm$ 2 km. The system in use since 1960 at Adelaide, Australia (Weiss and Elford, 1963, Roper, 1965) satisfied these criteria, and was used as a starting point for the design of the Georgia Tech system.

Two significant changes were deemed essential. First, the system must record echoes on magnetic tape, and not on film, and second, an alternate echo ranging system was desirable, to eliminate the companion pulse transmitter as used at Adelaide.

The first criterion was met by the design of an analog to digital hardware interface between the receiver outputs and a Kennedy Model 1610 incremental tape recorder. The second, by using a double sideband suppressed carrier continuous wave transmitter, and the range finding method detailed by Spizzichino (1972).

Equipment: The Transmitter

The transmitter (Roper, 1974a) is located on campus, on the fourth floor of the Montgomery Knight building of the School of Aerospace Engineering of the Georgia Institute of Technology. An oven mounted third overtone crystal oscillating on 32.5 MHz is the frequency controlling element; the oscillator output is buffered, and used to drive a high level balanced modulator - a pair of 4-1000A tetrodes, with control grids in push-pull, screen grids in push pull, and plates in parallel (block diagram, Figure 1). R. F. excitation is applied to the control grids, and, in the absence of screen modulation, there is no output from the plate circuit. When the screens are modulated in push-pull with a 360 Hz signal, double sideband suppressed carrier output is produced, which consists of two frequencies at 32.5 MHz + 360 Hz and 32.5 MHz - 360 Hz. An RMS power of 1 KW in each sideband is radiated from a dipole antenna mounted $3\lambda/8$ above the roof of the Aerospace Engineering building.

Equipment - The Receiving Site

The receiving site (Roper, 1974b) is located at Technology Park/Atlanta, 27 km northeast of the transmitter. Separation and terrain are such that each $\lambda/2$ dipole antenna, $\lambda/4$ above ground, feeds a signal of 10 microvolts (across 75 ohms) to the input of its associated receiver.

The direction finding system is similar to that employed at Adelaide. Each of the 5 antennae of Figure 2 feeds a separate receiver. Each receiver (block diagram, Figure 3) has an F.E.T. R.F. amplifying stage, followed by a dual gate F.E.T. mixer with output on 9 MHz. Mixer injection is provided by a common 23.5 MHz crystal controlled oscillator. The signal is amplified in a 2.5 KHz bandwidth integrated circuits I.F. amplifier, and mixed again with the output of a second common oscillator on 8.99852 MHz to produce two output frequencies - 1840 Hz for the 32.5 MHz + 360 Hz ground wave, 1120 Hz for the 32.5 MHz - 360 Hz ground wave; each receiver then feeds an 1840 Hz $\pm$ 50 Hz bandpass filter. Receiver 2 (see Figure 4) also feeds an 1120 Hz $\pm$ 50 Hz bandpass filter. In order to keep the groundwaves centered in their respective filters, a sixth antenna, a 4 element Yagi, mounted atop a 13 meter tower and pointing directly at the transmitter, feeds a sixth receiver which drives an 1840 Hz discriminator, the output of which is applied as an A.F.C. voltage to the second local oscillator feeding all receivers. The characteristics of the yagi antenna and its associated receiver are such that only 1840 Hz "groundwave" energy appears at the discriminator, and the automatic frequency control is not affected by the presence of signal echoes. The 1840 Hz output of this receiver is also used to cancel the 1840 Hz ground wave in the echo sensing output channel of receiver 2.

Measurement of Echo Arrival Angle

The presence of a signal other than ground wave in the echo sensing channel triggers the digital logic interface between the receiver outputs and the Kennedy 1610 incremental tape recorder. For direction finding, relative phases between receiver outputs are determined by integration over 3/2 cycles of doppler waveform. This places quite a severe restriction on the number of acceptable echoes, but ensures that each echo accepted meets the requirements placed on echo arrival angle. Very short duration echoes (decay times < 40 milliseconds) are not accepted - the body dopplers due to winds associated with such echoes are contaminated by the phase changes arising from the Fresnel pattern of trail formation. Only relative phases, and the doppler frequency, are stored in memory registers - arrival angles and doppler sign (sense of echo drift, toward or away from the transmit/receive system) are determined by subsequent computer analysis on campus of the tape record written after completion of the echo.

Range Determination

Two oscillations, commencing in phase with frequency difference Δf, will be in phase every $1/\Delta f$ seconds. The two signals radiated about 32.5MHz by the dsbsc transmitter have a Δf of 720 Hz, and will therefore be in phase every 1388.8 microseconds. This places an upper limit on the path difference for range measurement R_{MAX} of 1388.8 x c, where c is the velocity of light; thus, R_{MAX} = 416.350 km.

The doppler shifted skywaves (one for each transmitted sideband) reflected by a meteor trail which assumes aspect sensitivity within a cone of zenith angle 60^{0} relative to the transmit/receive system, and which produce an acceptable line if sight shift (between 2 Hz and 40 Hz) will, when combined individually with the appropriate groundwave sideband at the receiving site, produce doppler beat waveforms whose phase relationship is the same as that or the original R.F. waveforms. If the transmitting and receiving sites coincide (as in a conventional radar) the phase difference ϕ between the outputs from the 1120 Hz and 1840 H channels of receiver 2 depends on the range R such that

$$\phi = \frac{4\pi R \Delta f}{c}$$

i.e.

$$R = \frac{1}{4\pi}\frac{c}{\Delta f}\,\phi$$

Again, only the phase difference is measured at the receiving site. The appropriate echo range is subsequently computed on campus, using a computer program which solves for the echo position on the minimum path ellipse specified by the measured ϕ and the transmit/receive system geometry.

Data Output

The doppler speed and relative phases are parallel loaded into 8 16 bit binary registers during the duration of the first 3/2 cycles of each echo. Year, day of year, hour, minute, and second are continuously updated in 13 4 bit BCD registers. The loaded registers are then written serially onto tape by the Kennedy 1610 deck as 5 36 bit words, followed by an inter-record gap, a format compatible with the UNIVAC 1108 computer on campus; tapes are changed every other day, and the approximately 1000 echoes per day subsequently processed on campus.

Data Reduction

All data tape processing is performed on the UNIVAC 1108 computer in the Office of Computing Services on the Georgia Tech campus. A complete library of FØRTRAN computer programs handles the data reduction, from determination of echo arrival angle, range, trail drift velocity (with sign), and time of occurrence of echo from the digital data packed onto the receiving facility output tape, to the plotting of the height/time wind profiles, and altitude dependent wind spectra deduced from the echo data. These programs are adaptations of routines originally developed by the author and Dr. W. G. Elford for the Adelaide radio meteor wind system. Considerable modification has been made to the program which processes the tape generated at the receiving site to replace previously used approximations made in the geometry of echo detection with analytic solutions. Optimization of data handling, and the use of UNIVAC FØRTRAN V coding where efficiency is increased, together with the addition of graphic output routines, results in a most comprehensive meteor wind data reduction library.

Synopsis of the Computer Reduction and Analysis Programs.

Program DECØDE reads the echo data tapes, unpacks the data words, tests each record for consistency of doppler waveform (over 1 1/2 cycles) and echo height, and, if acceptable, calculates the drift velocity, direction of arrival and echo height from the recorded phase information. At the option of the user, this information, together with the date and time of occurrence of the echo, is stored on disc, written on mag. tape or punched on cards. Execution time ∿ 15 seconds/1000 echoes.

PRØGRAM GRØVES

performs the height/time wind analysis of Groves (1959), fitting by the method of least squares, polynomials in height and Fourier series in time to the echo by echo output from DECØDE. In routine analysis, cubic variations with height in the NS and EW components, a constant vertical wind (rarely statistically different from zero), and prevailing, 24 hour, 12 hour, and 8 hour variations are determined, but all of these parameters can be modified to produce a better fit of the model to the data. Execution time ∿ 50 seconds/1000 echoes.

PROGRAM PLØTGM

takes the coefficients of the GROVES model and countour plots the best fit height time profiles on a 24 hour interval. Execution time ∿ 10 seconds.

PRØGRAM ERG

utilizes the basic analysis of Groves, to perform a periodogram analysis of the echo by echo data to produce altitude dependent amplitude and phase spectra for the NS, EW, and vertical wind components. Spectra are normally computed at 2 km height intervals over the frequency range 0.5 to 4.0 cycles per day. However, both the height interval and frequency range are programmer specified options. Available resolution depends on the data density and length of the data interval. Printed output, and tape or disc output, are produced. Execution time ∿ 600 secs/1000 echoes.

PRØGRAM SCRAWL

is a utility routine which takes a "quick look" at the ERG output file and plots the results on a computer page. A CALCØMP plotter routine is available to produce illustrations for publication. SCRAWL also tabulates statistics of the variation of wind component energy with height. Execution time ∿ 2 seconds per spectrum.

PRØGRAM TRANSF

performs the transform of the spectra output by ERG to produce hour by hour profiles for the data gathering interval. This procedure gives much better insight into the day by day variability than is possible with day by day application of PRØGRAM GRØVES. A CALCØMP plotter routine is also available for this output. Execution time ∿ 20 seconds.

PRØGRAM MIRREG

uses the GRØVES output coefficients, and scans the echo by echo data to produce height/time profiles of the irregular wind component by subtracting the prevailing and tidal wind components. Contour plots of these variations can also be produced by PLØTGM. Execution time ∿ 10 seconds/1000 echoes.

These programs, together with program LØCATE, which determines the site constants appropriate to any specified transmit/receive locations, and program METEØR which generates artificial "echoes" for system simulation studies, are detailed in Roper (1974c). Some examples of the plotted outputs of GRØVES and ERG are given in Figures 5 and 6.

CONCLUSION

A highly reliable, relatively inexpensive CW meteor radar, capable of measuring the variation of wind speed with altitude to $\pm$ 3 m/sec, $\pm$ 2 km, is in operation in Atlanta (33^{o} N, 84^{o} W). It is hoped that this station will be operated continuously, providing data on the height/time variations of prevailing and tidal winds over the height range 80 to 100 km. Particular emphasis is being placed on the investigation of planetary wave amplitudes and frequencies, and, through GRMWSP - the Global Radio Meteor Wind Studies Project of the International Association of Geomagnetism and Aeronomy, on the synotpic meteorology of this region.

ACKNOWLEDGMENTS

The Georgia Tech Radio Meteor Wind Facility was initially funded by the Georgia Institute of Technology. Since 1971, it has been supported by the Atmospheric Sciences Section of the National Science Foundation under Grant GA26626.

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FIGURE CAPTIONS

Figure 1. Block diagram of the transmitter

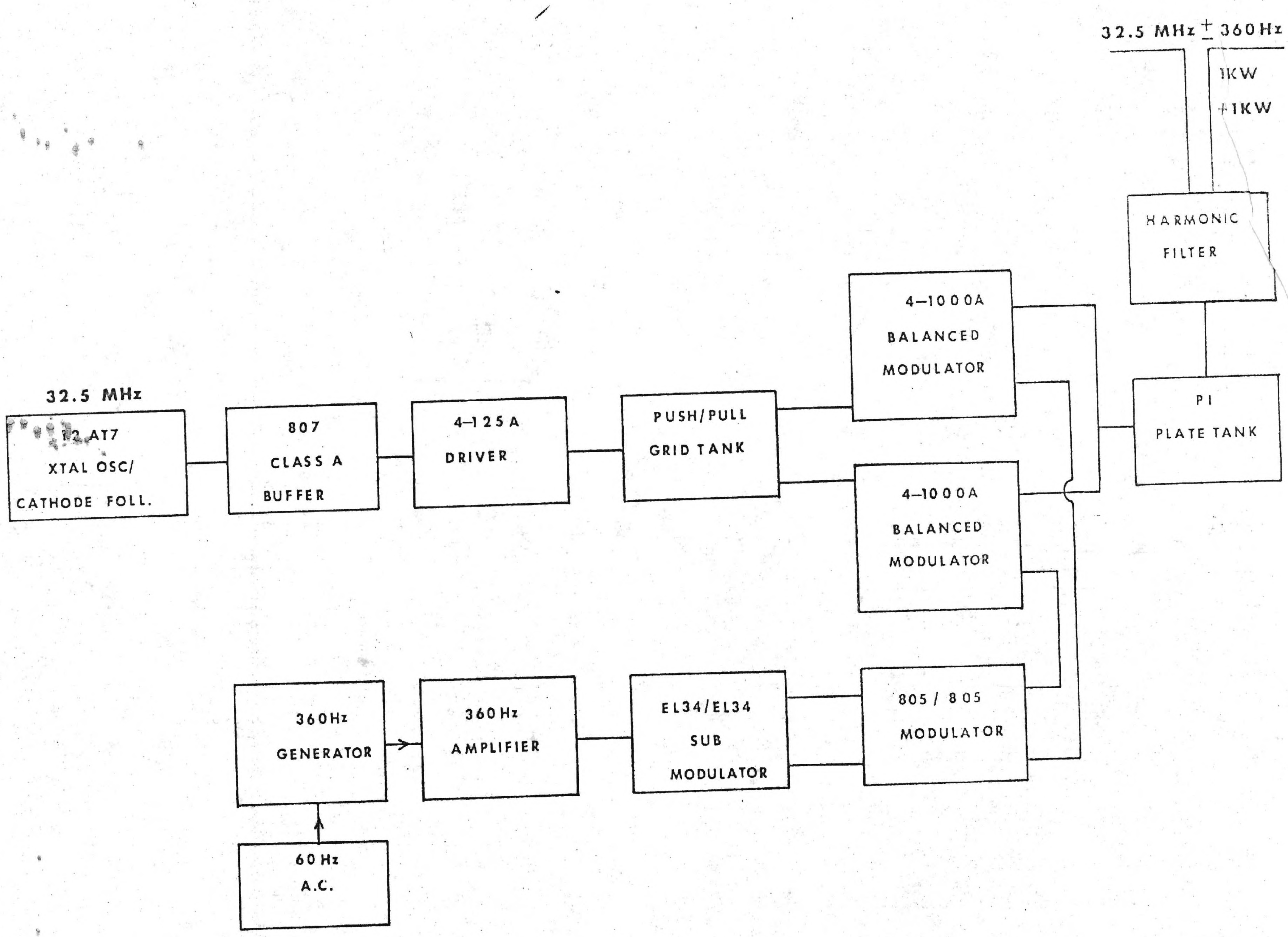
Figure 2. Layout of the direction finding antenna system

Figure 3. Direction finding receiver block diagram

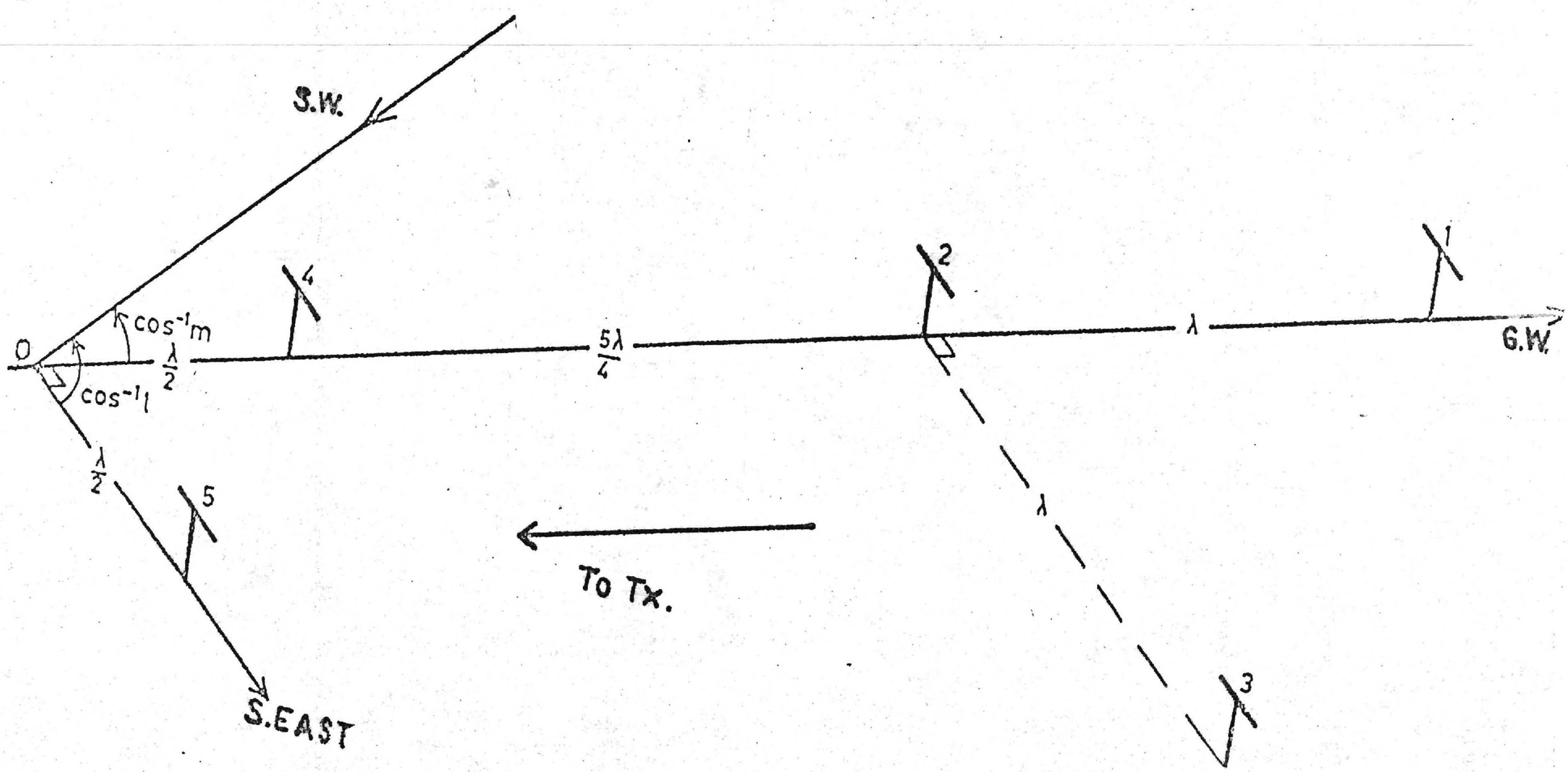
Figure 4. Block diagram of the receiving system

Figure 5. The zonal and meridional winds, composed of prevailing, 24, 12, and 8 hour components as determined by the method of Groves (1959), for the month of July, 1974.

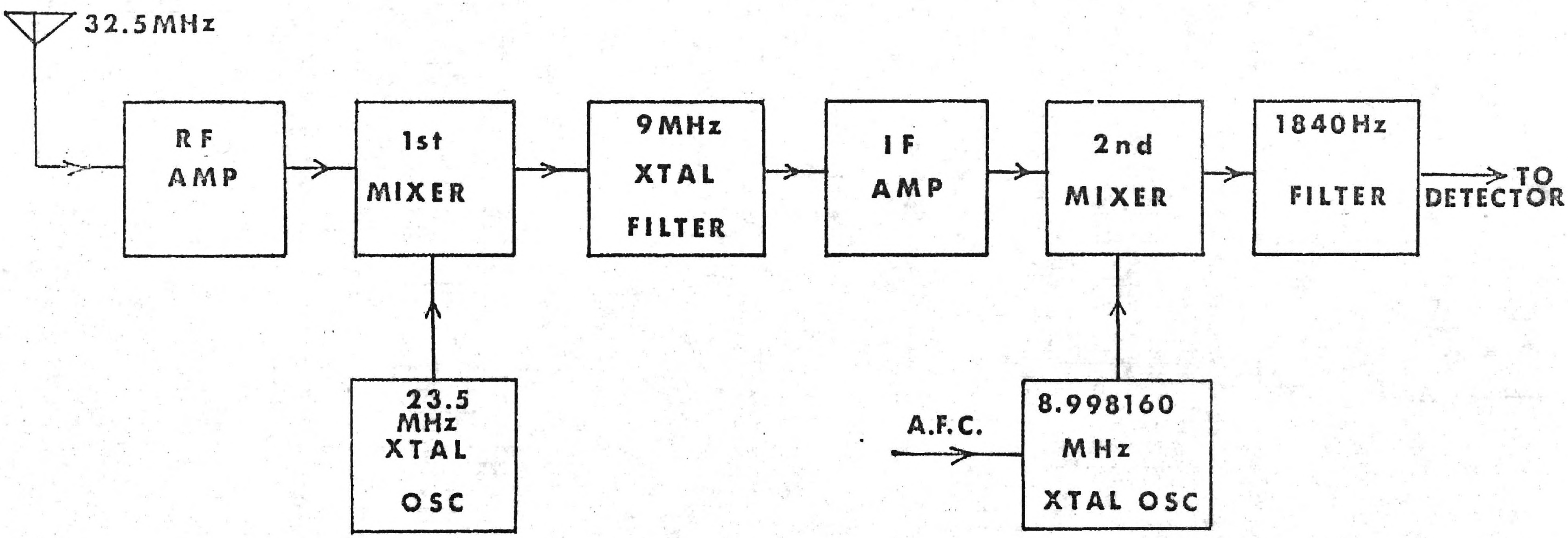
Figure 6. The wind energy per unit mass, defined as the sum of the squares of the zonal, meridional, and vertical wind velocities, for the month of July, 1974.

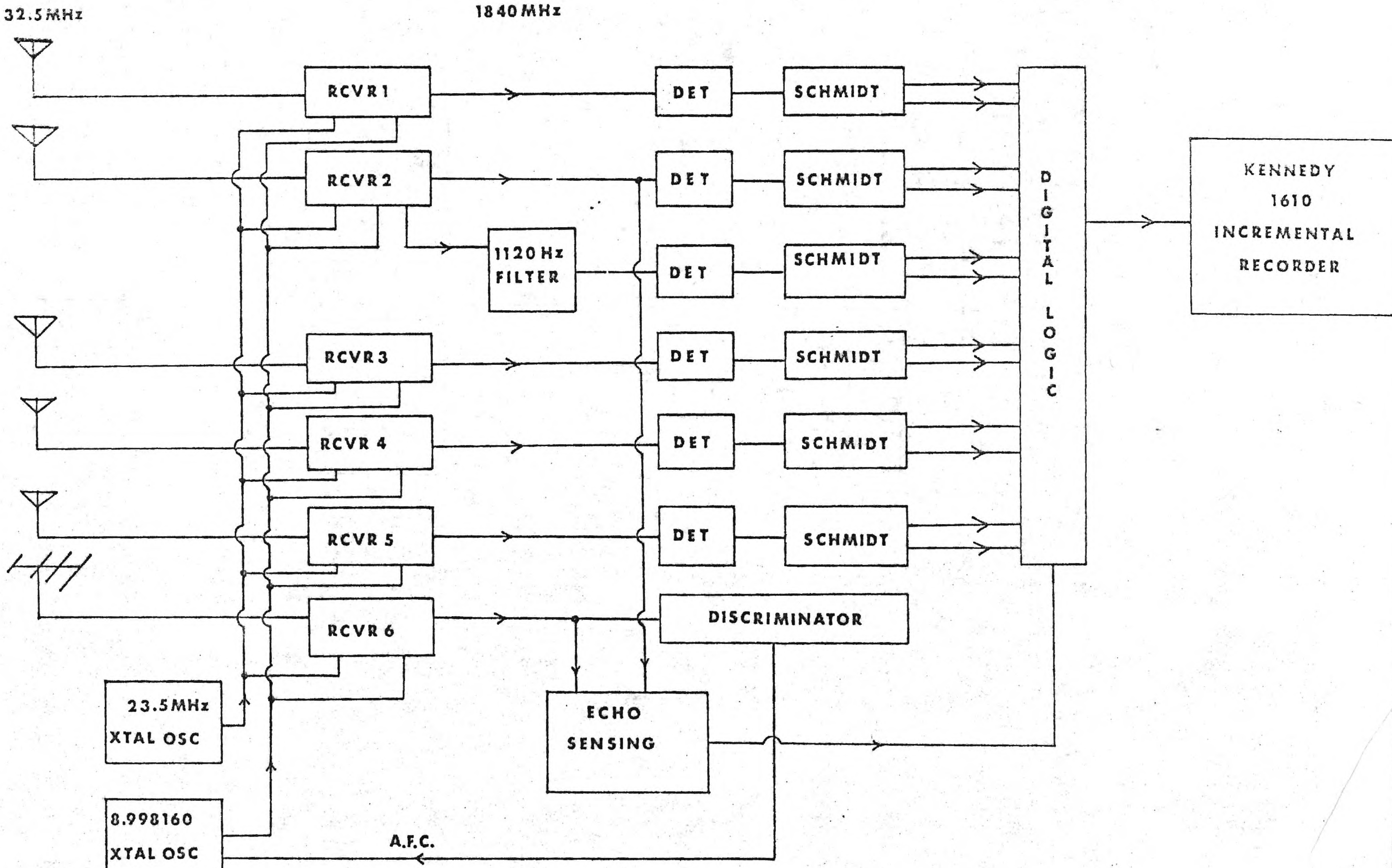


32.5 MHz ± 360Hz
1KW
+1KW
HARMONIC
FILTER
4–1000A
BALANCED
MODULATOR
PI
PLATE TANK
32.5 MHz
12 AT7
XTAL OSC/
CATHODE FOLL.
807
CLASS A
BUFFER
4–125A
DRIVER
PUSH/PULL
GRID TANK
4–1000A
BALANCED
MODULATOR
360Hz
GENERATOR
360Hz
AMPLIFIER
EL34/EL34
SUB
MODULATOR
805 / 805
MODULATOR
60 Hz
A.C.



S.W.
O
$\cos^{-1}m$
$\cos^{-1}l$
$\frac{\lambda}{2}$
4
$\frac{5\lambda}{4}$
2
λ
1
G.W.
$\frac{\lambda}{2}$
5
λ
To Tx.
S.EAST
3


32.5MHz
RF AMP
1st MIXER
9MHz XTAL FILTER
IF AMP
2nd MIXER
1840Hz FILTER
TO DETECTOR
23.5 MHz XTAL OSC
A.F.C.
8.998160 MHz XTAL OSC


32.5MHz
1840MHz
RCVR 1
RCVR 2
RCVR 3
RCVR 4
RCVR 5
RCVR 6
1120 Hz FILTER
DET
DET
DET
DET
DET
DET
SCHMIDT
SCHMIDT
SCHMIDT
SCHMIDT
SCHMIDT
SCHMIDT
DIGITAL LOGIC
KENNEDY 1610 INCREMENTAL RECORDER
DISCRIMINATOR
ECHO SENSING
23.5MHz XTAL OSC
8.998160 XTAL OSC
A.F.C.

TRIAL RUN OF GT DATA GATHERED JULY 19-25, 1974.   RUN ON AUG 7, 1974   ATLANTA   PAGE 6

(ALL DATA IN FILE)

NORTH-SOUTH COMPONENTS OF THE MEAN WIND, HOUR BY HOUR,

AS DETERMINED FOR THE HEIGHT RANGE 76 KM TO 106 KM.

HEIGHT	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
106	28.	12.	-2.	-10.	-15.	-18.	-19.	-19.	-13.	-1.	14.	27.	32.	25.	6.	-18.	-36.	-42.	-32.	-9.	17.	38.	46.	42.
104	22.	16.	7.	-3.	-11.	-17.	-19.	-18.	-13.	-5.	4.	10.	12.	8.	0.	-9.	-17.	-21.	-17.	-9.	3.	14.	22.	24.
102	18.	18.	12.	2.	-8.	-15.	-18.	-16.	-11.	-6.	-3.	-2.	-3.	-4.	-4.	-5.	-5.	-6.	-8.	-9.	-7.	-2.	5.	13.
100	15.	18.	14.	4.	-6.	-13.	-15.	-12.	-8.	-5.	-7.	-10.	-13.	-12.	-8.	-2.	2.	2.	-3.	-9.	-13.	-12.	-4.	6.
98	14.	18.	14.	5.	-5.	-11.	-11.	-7.	-4.	-4.	-8.	-14.	-19.	-18.	-11.	-2.	4.	5.	-1.	-9.	-16.	-15.	-8.	4.
96	14.	17.	13.	4.	-4.	-8.	-7.	-3.	0.	-2.	-8.	-16.	-21.	-20.	-13.	-4.	3.	4.	-2.	-10.	-15.	-14.	-7.	5.
94	14.	15.	10.	3.	-3.	-4.	-2.	2.	4.	1.	-7.	-15.	-20.	-20.	-14.	-6.	-1.	-0.	-4.	-10.	-13.	-10.	-2.	7.
92	15.	13.	7.	1.	-2.	-1.	3.	7.	7.	3.	-5.	-13.	-18.	-18.	-14.	-9.	-6.	-6.	-8.	-10.	-8.	-3.	5.	12.
90	16.	11.	4.	-0.	-1.	2.	7.	10.	9.	4.	-3.	-10.	-14.	-15.	-14.	-12.	-12.	-13.	-13.	-10.	-3.	5.	13.	17.
88	16.	9.	2.	-1.	1.	6.	10.	12.	9.	4.	-2.	-7.	-9.	-11.	-12.	-15.	-18.	-20.	-17.	-9.	2.	13.	20.	21.
86	17.	7.	0.	-1.	3.	9.	12.	12.	7.	2.	-2.	-4.	-5.	-6.	-10.	-17.	-23.	-25.	-20.	-8.	7.	20.	26.	25.
84	16.	6.	1.	2.	7.	12.	13.	9.	3.	-2.	-4.	-3.	-0.	-1.	-7.	-17.	-26.	-28.	-22.	-7.	10.	25.	30.	26.
82	15.	7.	4.	6.	11.	14.	11.	4.	-4.	-9.	-8.	-3.	2.	3.	-4.	-15.	-25.	-28.	-21.	-5.	13.	26.	30.	25.
80	13.	8.	9.	13.	17.	16.	7.	-5.	-15.	-19.	-15.	-6.	3.	6.	0.	-11.	-20.	-23.	-17.	-3.	12.	23.	25.	20.
78	8.	11.	18.	24.	25.	17.	1.	-17.	-30.	-33.	-25.	-12.	1.	7.	5.	-3.	-11.	-13.	-9.	0.	9.	14.	13.	10.
76	3.	16.	30.	38.	34.	17.	-9.	-34.	-49.	-51.	-40.	-22.	-4.	7.	10.	8.	5.	3.	4.	4.	2.	-2.	-6.	-5.

FIGURE 5b

TRIAL RUN OF GT DATA GATHERED JULY 19-25, 1974. RUN ON AUG 7, 1974 ATLANTA PAGE 5

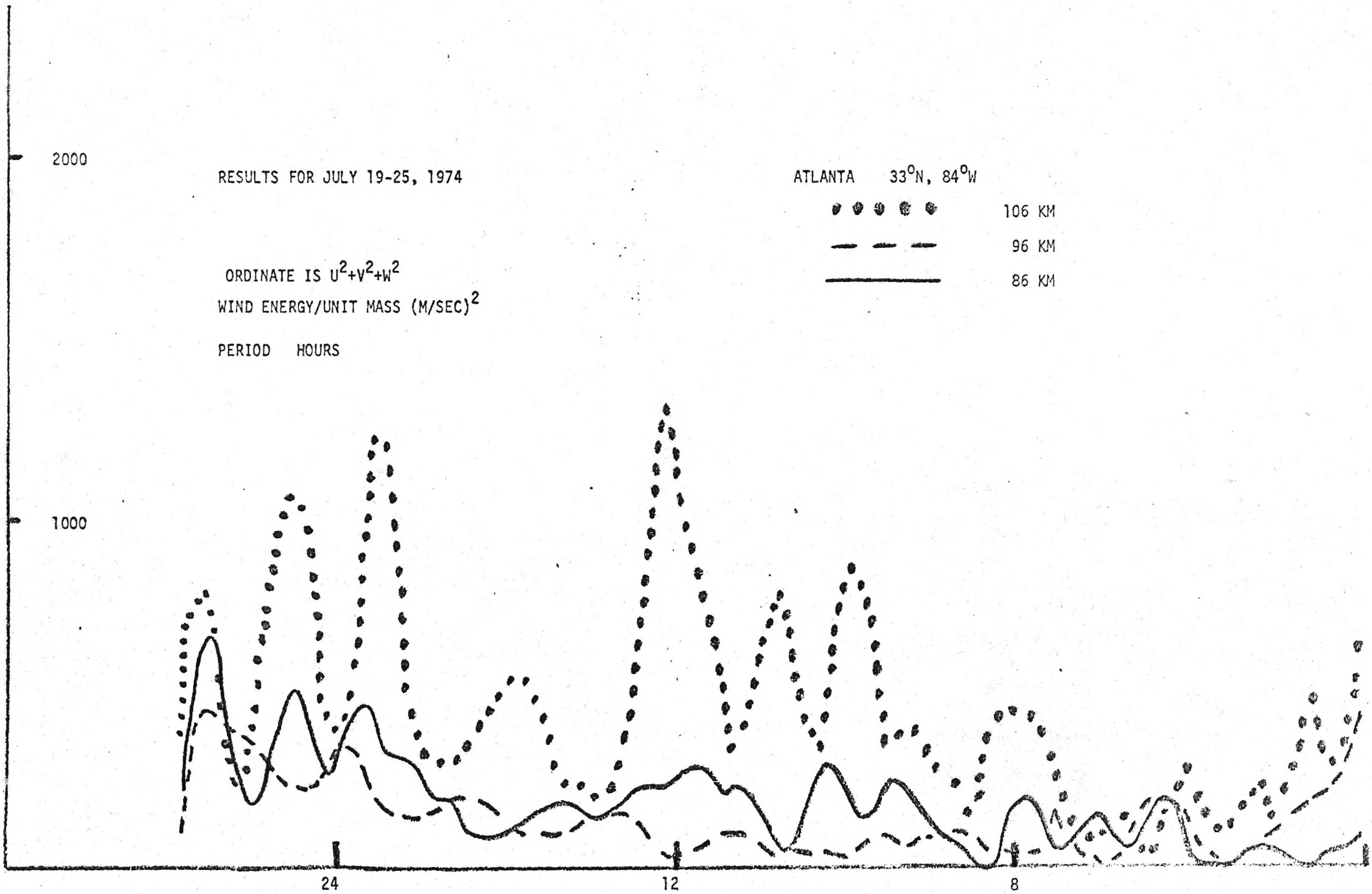
(ALL DATA IN FILE)

EAST-WEST COMPONENTS OF THE MEAN WIND, HOUR BY HOUR,

AS DETERMINED FOR THE HEIGHT RANGE 76 KM TO 106 KM.

HEIGHT	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
106	-15.	-26.	-21.	-4.	15.	26.	26.	18.	11.	11.	20.	31.	35.	27.	6.	-18.	-33.	-31.	-12.	15.	38.	44.	32.	8.
104	-1.	-7.	-5.	3.	12.	17.	18.	15.	13.	15.	21.	28.	30.	25.	13.	8.	-8.	-8.	2.	15.	26.	29.	23.	11.
102	7.	5.	5.	7.	9.	10.	11.	12.	14.	18.	22.	25.	25.	22.	17.	12.	9.	8.	11.	15.	18.	13.	15.	11.
100	10.	11.	10.	9.	7.	6.	6.	9.	14.	18.	21.	22.	22.	20.	19.	18.	18.	18.	16.	14.	12.	10.	9.	9.
98	10.	12.	11.	8.	4.	2.	3.	7.	12.	17.	19.	20.	19.	18.	19.	21.	22.	22.	19.	13.	8.	4.	4.	7.
96	7.	9.	9.	6.	2.	-0.	1.	5.	10.	15.	17.	17.	16.	16.	17.	19.	21.	21.	18.	12.	6.	2.	1.	3.
94	2.	4.	4.	3.	0.	-1.	-1.	3.	7.	12.	15.	15.	14.	14.	14.	16.	17.	18.	15.	11.	5.	1.	-1.	-1.
92	-4.	-3.	-2.	-1.	-1.	-2.	-1.	1.	5.	9.	12.	13.	13.	12.	10.	10.	11.	12.	11.	9.	6.	1.	-2.	-4.
90	-9.	-10.	-8.	-5.	-3.	-1.	-1.	0.	2.	6.	9.	11.	11.	10.	7.	4.	4.	5.	6.	8.	7.	3.	-1.	-6.
88	-13.	-16.	-14.	-10.	-5.	-1.	0.	0.	1.	3.	6.	9.	10.	8.	4.	-1.	-4.	-3.	1.	6.	8.	6.	0.	-7.
86	-15.	-20.	-19.	-13.	-6.	-1.	1.	1.	0.	1.	4.	8.	9.	7.	1.	-5.	-9.	-9.	-3.	4.	10.	9.	3.	-6.
84	-14.	-21.	-21.	-16.	-8.	-1.	2.	2.	0.	0.	2.	6.	8.	6.	0.	-7.	-13.	-13.	-7.	3.	10.	13.	8.	-3.
82	-8.	-18.	-21.	-17.	-9.	-1.	4.	4.	2.	1.	1.	4.	6.	5.	1.	-6.	-12.	-13.	-8.	1.	10.	15.	13.	4.
80	3.	-9.	-16.	-17.	-11.	-3.	5.	8.	6.	3.	1.	2.	4.	5.	4.	-1.	-6.	-10.	-8.	-1.	9.	17.	19.	14.
78	20.	7.	-6.	-14.	-13.	-5.	5.	12.	13.	8.	3.	-0.	1.	6.	10.	10.	6.	-1.	-4.	-2.	6.	18.	27.	28.
76	45.	30.	9.	-8.	-15.	-8.	5.	17.	21.	16.	5.	-2.	-2.	7.	19.	27.	25.	15.	3.	-4.	2.	17.	35.	47.

FIGURE 5a



2000
1000
RESULTS FOR JULY 19-25, 1974
ORDINATE IS $U^2+V^2+W^2$
WIND ENERGY/UNIT MASS $(M/SEC)^2$
PERIOD HOURS
ATLANTA 33°N, 84°W
106 KM
96 KM
86 KM
24
12
8

FIGURE 6

E-16-615

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Final Technical Report on research supported by the Atmospheric Sciences Section, National Science Foundation, under Grant No. GA26626.

Georgia Tech Project No. E-16-615

Contract Period March 15, 1971 - May 31, 1975

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PREFACE

The Georgia Tech Radio Meteor Wind Facility is the result of a long-term crystallization of ideas over some eighteen year of involvement in the measurement and interpretation of radio meteor winds. The Tech system is not the ultimate in radio meteor facilities. It is designed for one purpose - the continuous measurement of line of sight meteor trail drifts in the altitude range 80 to 100 km, and their interpretation as height/time variations in the prevailing and tidal wind field at these altitude with as little delay as possible. By the use of digital recording on magnetic tape, and the library of computer programs detailed in this report, printouts and plots of the wind components are available within hours of returning a data tape from the field site. Coupled with the stability inherent in the use of a CW technique, and the simplicity, reliability and low cost (both initial and operating) of the installation, the Georgia Tech Radio Meteor Wind Facility represents an almost ideal solution to the problem of the continuous measurement of prevailing and tidal winds in the meteor region of the upper atmosphere.

This report contains the three volumes:

The Georgia Tech Radio Meteor Wind Facility Transmitter

The Georgia Tech-Technology Park/Atlanta Radio Meteor Wind Facility Receiving Equipment

and

The Georgia Tech Radio Meteor Wind Facility Computer Program Library.

ACKNOWLEDGMENTS

The work documented in this report was initially supported by the Georgia Institute of Technology. Since 1971, additional support has been received from the Atmospheric Sciences Section of the National Science Foundation, under Grant No. GA26626. Appreciation is expressed to Dr. K. C. Clark, Dr. R. I. Schoen, Dr. M. H. Rees, and Dr. L. R. Megill, who monitored this grant while each was at NSF. Special mention must be made of Michael T. Flynn, who fabricated most of the transmitter, John Caudell, who designed and built the receivers, and Barry Platt, who wired the digital logic designed by C. R. Romanchuck. L. Willard, J. Palfery, R. Shepard, and G. Durden assisted in the establishment of the field site at Technology Park/Atlanta. The efforts of Joe W. Guthridge, Georgia Tech Vice President for Development; the management of Technology Park/Atlanta, who provided the field site; and then Dean of Engineering T. E. Stelson, for allocation of funds for the purchase of the trailer housing the receiving equipment, are gratefully acknowledged. Students V. N. Parekh, David Dameron, C. Morina, S. Sawilosky, T. Grems, and R. Krone assisted in equipment construction, computer programming, and drafting. G. J. Flaque and G. Morrison obtained Masters Degrees while working on the project. M. L. Salby and P. M. Dolas are currently involved as Ph.D. candidates.

The transmitter was initially operated under the supervision of the late Charles Lord. The present station engineer is Gene Greneker.

Typing of numerous proposals and reports, including this, has been ably handled by Ann Dillon.

R. G. Roper
May 1975

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THE GEORGIA TECH RADIO METEOR WIND FACILITY THREE KILOWATT DOUBLE SIDEBAND SUPPRESSED CARRIER 32.5 MHz TRANSMITTER

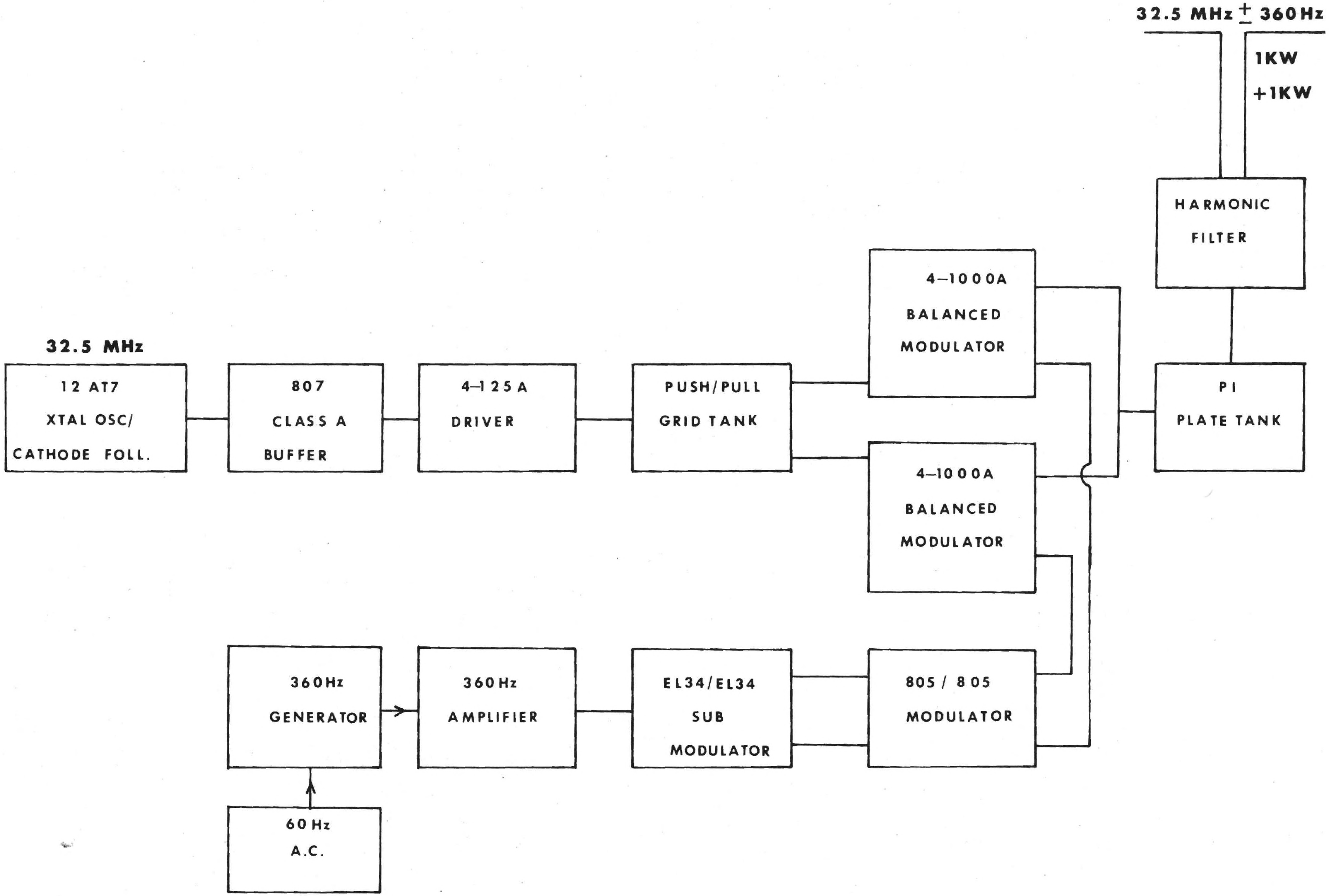
THREE KILOWATT DOUBLE SIDEBAND SUPPRESSED CARRIER
32.5 MHz TRANSMITTER

INTRODUCTION

The Georgia Tech Radio Meteor Wind Facility was designed to meet the following criteria -

1. Continuous operation, 24 hours a day, 7 days a week with an adequate useable echo rate (> 500 echoes/day).
2. "All sky" system, with echo arrival angle and range measured.
3. Continuous wave, with groundwave/skywave beat specifying trail drift doppler.
4. Minimum bandwidth ($\pm$ 50 Hz) commensurate with doppler spectrum.
5. Data output on magnetic tape.

The design of the transmitter is contingent on 1, 2, and 3. These criteria, with the exception of range, which was measured by a supplementary pulse transmitter, were satisfied by the 1.25 KW CW transmitter previously designed for the system in use at the Physics Department of the University of Adelaide. By using the double sideband suppressed carrier technique, utilized by the French group at Garchy (Spizzichino, 1972) and at College, Alaska (Hook, 1970), range can be measured by phase comparison of the two beats produced by the skywave/groundwave interaction at each of the sideband frequencies. In the Georgia Tech system, two frequencies 720 Hz apart are transmitted giving a maximum range before ambiguity of 208 km, with an error of $\pm$ 2 km - inadequate for the direct measurement of small scale wind structure, but well within the requirements for prevailing wind, planetary scale waves and tidal oscillations.


32.5 MHz $\pm$ 360Hz
1KW
+1KW
HARMONIC FILTER
4–1000A BALANCED MODULATOR
32.5 MHz
12 AT7 XTAL OSC/ CATHODE FOLL.
807 CLASS A BUFFER
4–125A DRIVER
PUSH/PULL GRID TANK
PI PLATE TANK
4–1000A BALANCED MODULATOR
360Hz GENERATOR
360Hz AMPLIFIER
EL34/EL34 SUB MODULATOR
805 / 805 MODULATOR
60 Hz A.C.

Because of the signal to noise enhancement over the Adelaide system due to the use of a much smaller receiver bandwidth, a couple of hundred watts of transmitted power meets the minimum echo rate requirement. The present transmitter described here produces a radiated power of 1 KW in each sideband, and a useable echo rate of 500 per day.

The major disadvantage of the CW technique is the inability to record through interference, and in particular while aircraft reflections are present. In the Atlanta area, there is nearly always a small aircraft produced doppler beat present, and this source of interference results in the loss of some 50% of all otherwise useable echoes.

THE EXCITER

Because of the small receiver bandwidth ($\pm$ 50 Hz), the transmitter frequency is controlled by a crystal in an oven (75° C $\pm$ 1°). The warm up drift from a cold start is $\approx$ 400 Hz, but this is adequately taken care of by the automatic frequency control circuitry at the receiving station. (In the interests of minimal interference to other services, adequate transmitter frequency stability was deemed essential even though receiver AFC is available).

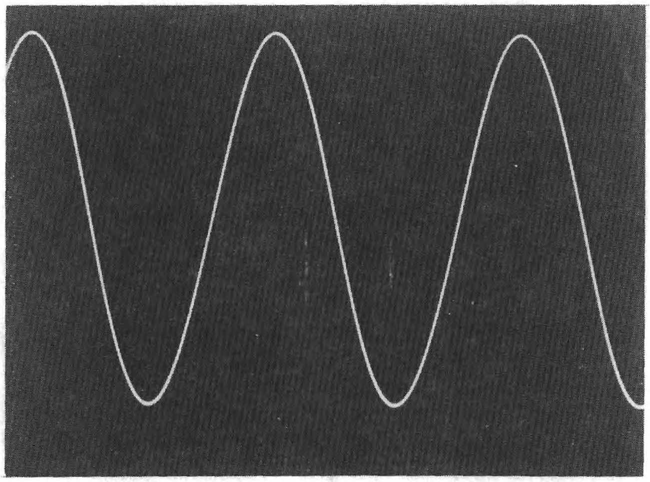
The crystal is resonated to 32.5000000 MHz by the air trimmer from oscillator (1/2 12AT7) grid to ground. Oscillator plate voltage is stabilized by an OB2 voltage regulator. The other 1/2 12AT7 operates as a cathode follower, which drives an 807 as a class A buffer. This stage in turn drives a class C 4-125A driver stage, providing some 60 watts CW drive to the final. All stages are operated on 32.5 MHz to minimize spurious output frequencies, and because of the extensive shielding between stages, no instability is in evidence.

THE FINAL

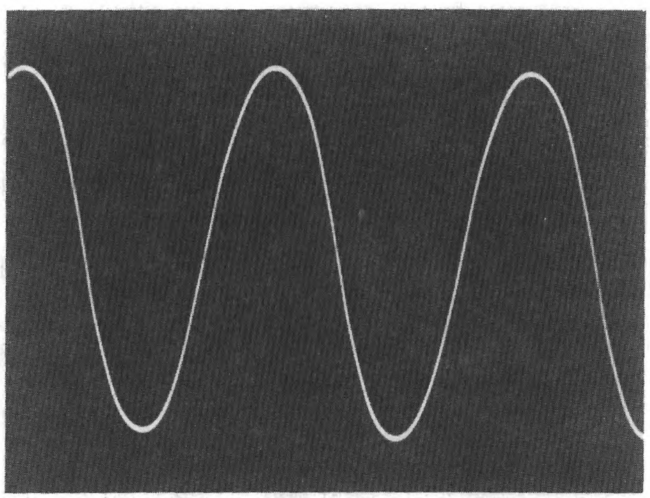
To produce the two output frequencies, 32.5 MHz $\pm$ 360 Hz, a high level balanced modulator is used. The technique is definitely brute force, but produces a reliable double sideband suppressed carrier signal with minimum complication.

The grids of a pair of 4 - 1000 A's are driven in push/pull by the 32.5 MHz output from the exciter. Since the plates of the 4 - 1000 A's are connected in parallel, there is no 32.5 MHz output. However, the screens are modulated with a push/pull 360 Hz signal, which results in a double sideband suppressed carrier output of two constant frequencies at 32.5 MHz $\pm$ 360 Hz. A standing bias of -60V on the final screens was found experimentally to result in minimum cross over distortion of the output waveform and fortuitously reduces the final plate dissipation to less than 500 w per tube in the absence of screen modulation.

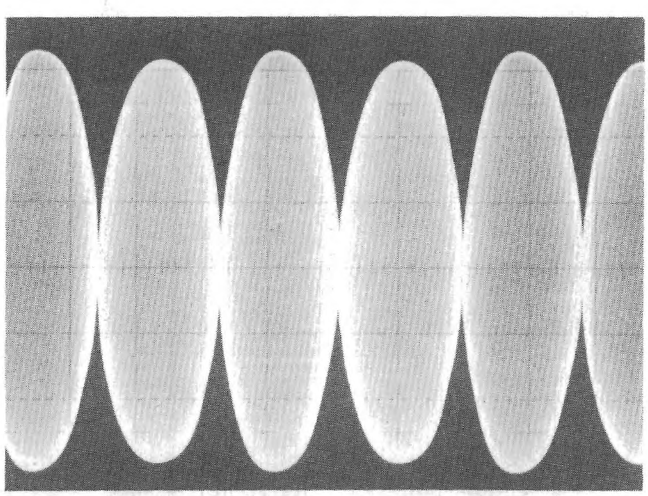
The excellent stability of the high level balanced modulator results from the use of adequate parasitic suppressors in both grid and plate circuits, the self neutralization inherent in the push/pull grids - parallel plates connection, and the laminated mica/brass sheet screen and filament bypass capacitor unit. This capacitor was removed from the original FRT-15 Navy transmitter which provided the power supply rack and many of the transmitter components, and was modified to incorporate individual screen bypasses, instead of the common bypassing in the original. The extremely low inductance inherent in the design of this capacitor makes it an ideal filament/screen bypass element.



360Hz out of submodulator.



360Hz on final screens.



RF waveform radiated by antenna.

THE MODULATOR

A signal phase locked to the A.C. power lines is produced in the 360 Hz generator by full wave rectification of a 60 Hz signal derived from the power lines, and subsequent clipping and selective filtering with three 360 Hz resonant circuits and two 12AU7 tubes.

This signal is used to drive the submodulator, which is essentially a 10 watt output hi fi amplifier whose frequency response has been minimized so that it handles the 360 Hz signal with, to all intents and purposes, zero distortion. A pair of 6CA7/EL34 tubes, with 275 v on plate and screen, and -15v bias, with 10db of negative feedback to the cathode of 1/2 12AU7 driving a 12AU7 paraphase push/pull output amplifier, produce 10w at the secondary of the 10 K to 500 ohm output transformer with 3 v p/p of 360 Hz input. Three parasitics, one at about 1 MHz, and one at 200 KHz, and the third at 10 Hz, were cured with a 1000 pf from first 1/2 12AU7 plate to ground, a .002 mfd from output plate to plate, and a 0.1 mfd from paraphase input grid to ground respectively.

A 500 Ω push/pull transformer drives two zero bias class B 805's with 1 KV on the plates. To provide the push/pull drive to the transmitter final screens, back to back 60 Hz power transformers, which perform excellently at 360 Hz, are used. A 4:1 impedance step up is provided by feeding the 230 v winding on the 805 plate transformer into the 115 v winding on the final screen transformer; the 630 v/630 v winding returns to the -60 v relay supply. The relatively high final screen impedance is effectively matched to the plates of the 805's.

THE ANTENNA COUPLER

In order to match the approximately 50 Ω unbalanced output impedence of the transmitter final pi tank circuit to the 100 Ω balanced feedline to the antenna, an antenna coupler unit is used. As a bonus, the coupler also introduces additional selectivity between the transmitter and the antenna, minimizing harmonic radiation. (Somewhat surprisingly, the distortion in the transmitter output, being considered as the sum of the unwanted suppressed carrier sidebands due to harmonics of the 360 Hz modulation, and higher order multiples of all output frequencies, represent a power which is more than 30 db down on the desired sidebands. This is due in no small measure to the inherent stability of the stage, as previously detailed, the care taken in balancing both the amplitudes and the phases of the drive to the final grids, the balancing of the screen modulation voltages, and the overall symmetry of the balanced modulator layout).

Even though both input and output circuits of the coupler operate at relatively low impedances, coupler Q is about 5, and so voltages of the order of 2 KV appear across the various reactances. The use of high voltage transmitting capacitors, and 1/4" diameter copper tubing inductors, results in a very smoothly tuning, negligible loss coupler.

To facilitate the original tune up of the coupler (in particular, in balancing the power fed to each of the coax cables comprising the 100 Ω balanced line) and for subsequent monitoring of transmitter output and antenna reflectance, two monomatch couplers are incorporated in the feeds to the output cables. Each output power indicator works as in the conventional unbalanced monomatch, but the reflected power is not measured on a balanced line as in the unbalanced case - in fact, when used conventially the "reflected power" indicated equals the forward power! Thus the two "reflected power" outputs are connected in antiphase, to produce a reading only when the lines are unbalanced.

THE ANTENNA

The spacing of an antenna above ground affects:

1. Elevation angle of maximum radiation.
2. Radiation resistance.

An all sky antenna should have an isotropic radiation pattern with one only maximum radiation "lobe" at 45° elevation. A $\frac{\lambda}{2}$ dipole $\frac{3\lambda}{8}$ above ground has maximum radiation at 40° elevation, with no nulls, and a radiation resistance of 100 ohms. (F. E. Terman, "Radio Engineers Handbook", p. 79., 1943). Since sufficient RG17/AU was available for a double run to the antenna, a 100 Ω balanced feed, with the inner conductors soldered directly to the two copper elements of a half wave dipole mounted $\frac{3\lambda}{8}$ above the roof of the Aerospace Engineering building on campus was used. The length of the dipole was trimmed to resonance at 32.5 MHz as indicated by an antennascope connected across the transmitter end of the line.

In an effort to minimize the RF field strength within the Aerospace Engineering building, a one wavelength square ground mat was temporarily installed under the dipole. This did improve the situation, but some interference was still caused to sensitive, high impedance instrumentation. The mat was removed.

POWER SUPPLIES

The power supply rack of the FRT-15 was used with minor modifications. Original voltages used as supplied are:

4.2 KV (fused @ 1 amp)

-150 v bias to final

-100 v bias to driver

A dropping resistor reduces the 2000 v output to 1500 v (at 100 ma max.) for the plate of the exciter.

The 600 v supply was modified to solid state bridge rectifier, producing 1200 v (at 150 ma) for the 805 modulator plates, with the supply center tap providing the 600 v to the 807 buffer plate.

In the transmitter rack, a 250 v @ 0.25 amp supply feeds the 360 Hz generator and sub modulator, as well as providing 250 v to the exciter.

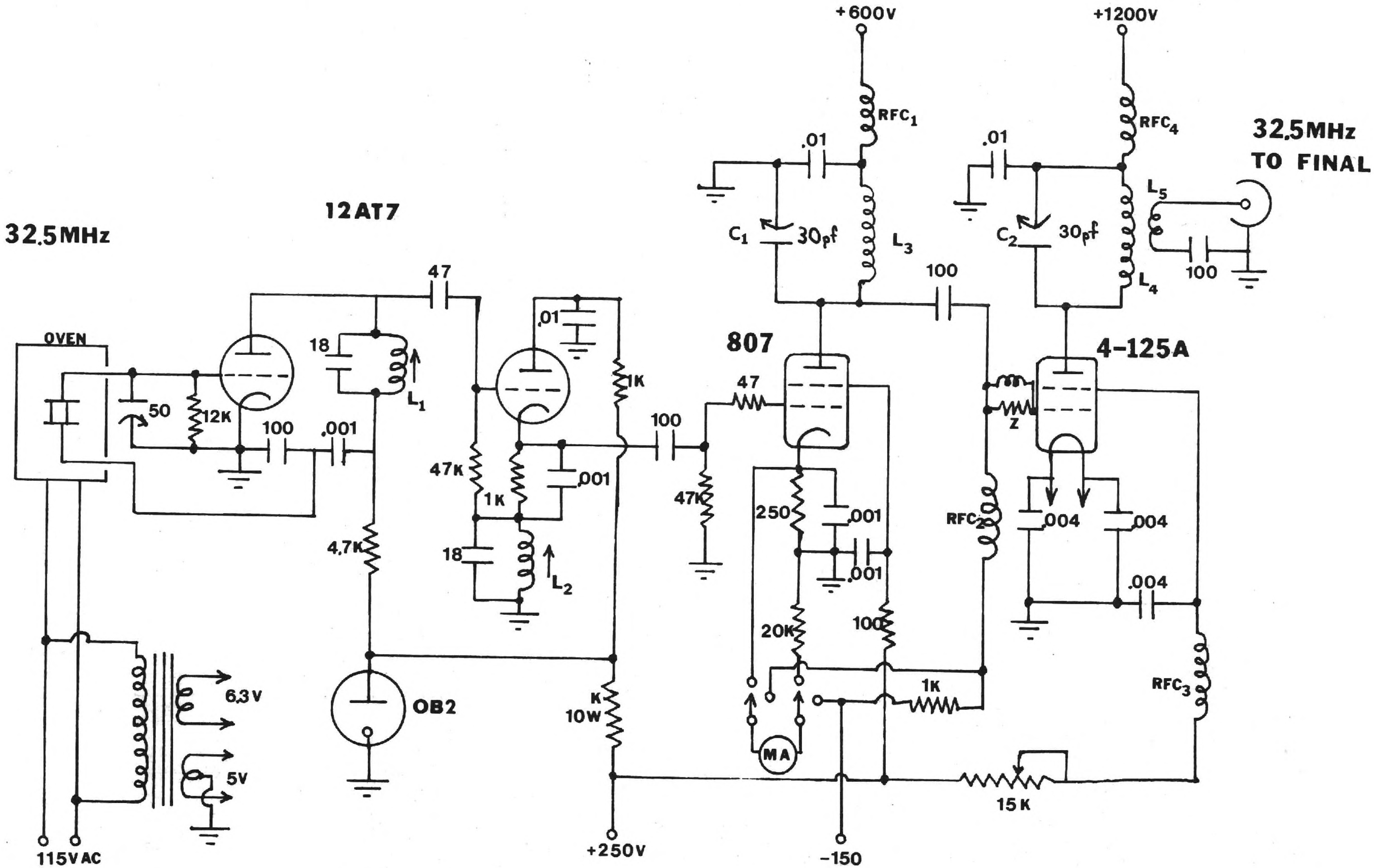
REFERENCES

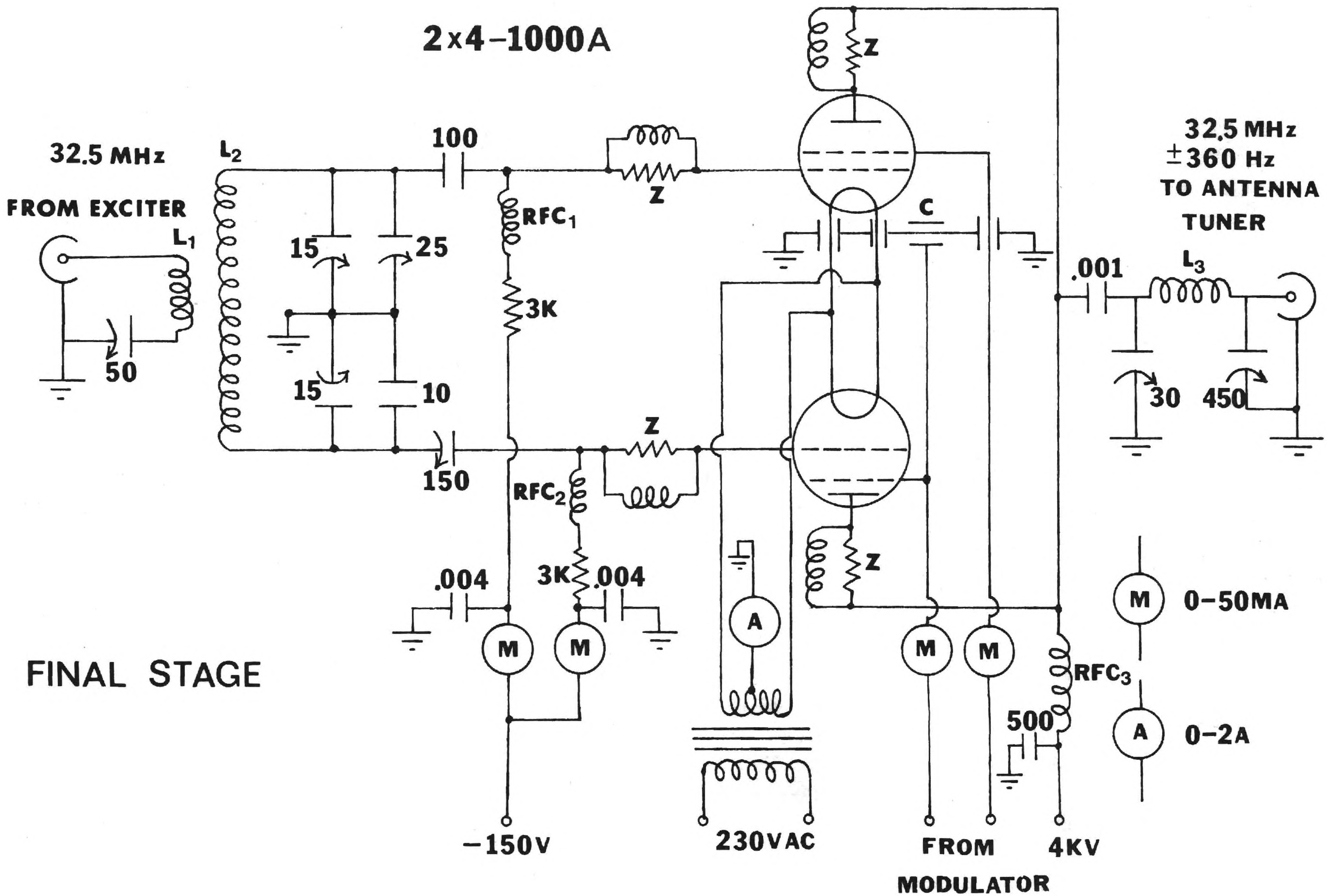
Hook, J. L., "Winds at the 75-110 Km Level at College, Alaska", Planet. Space Sci., 18, 1623-1638, 1970.

Spizzichino, Andre, "Meteor Trail Radar Winds Over Europe", in Thermospheric Circulation, ed. Willis L. Webb, M.I.T. Press, pp. 117-180, 1972.

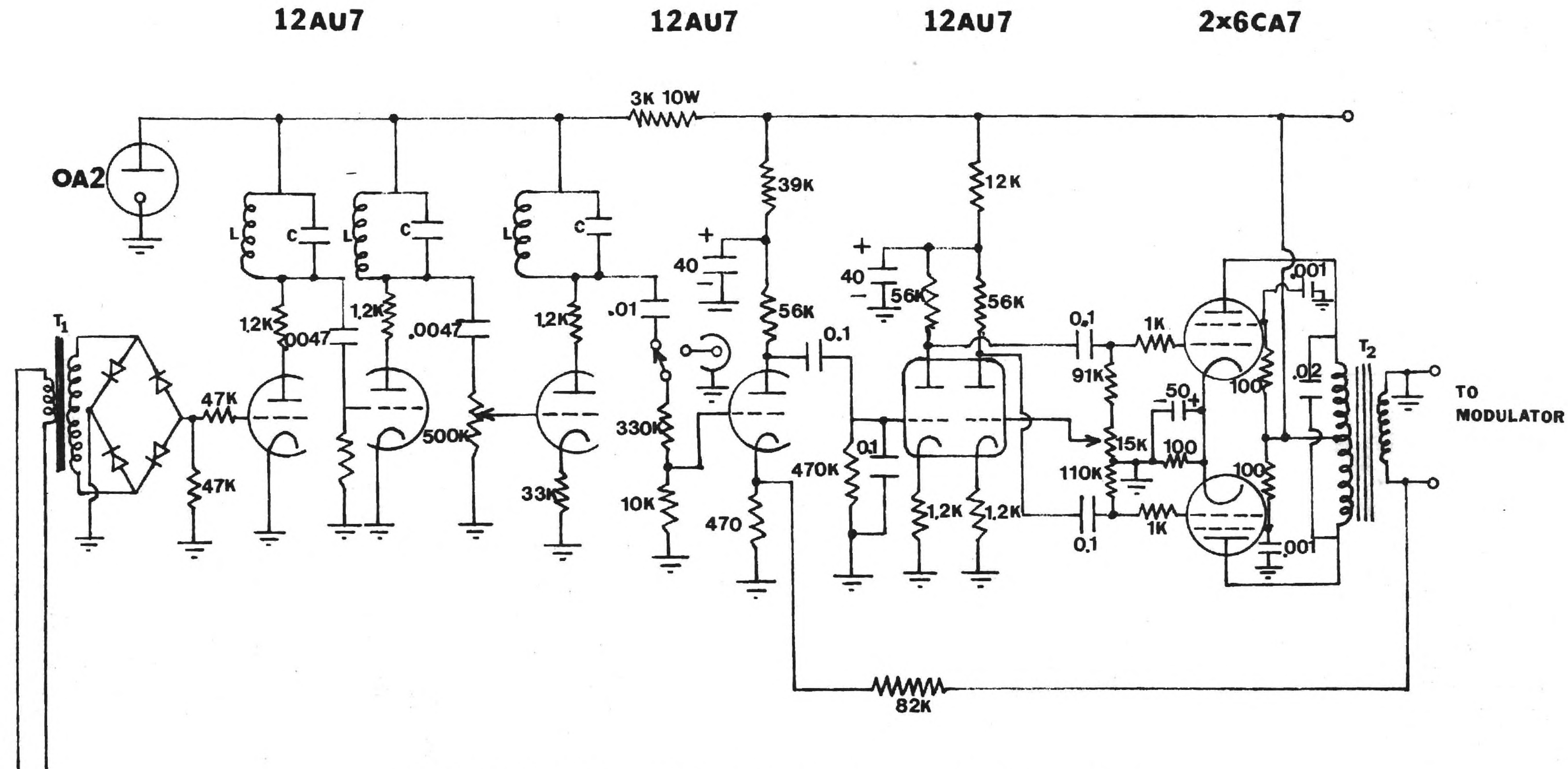
APPENDIX I

TRANSMITTER CIRCUIT DIAGRAMS

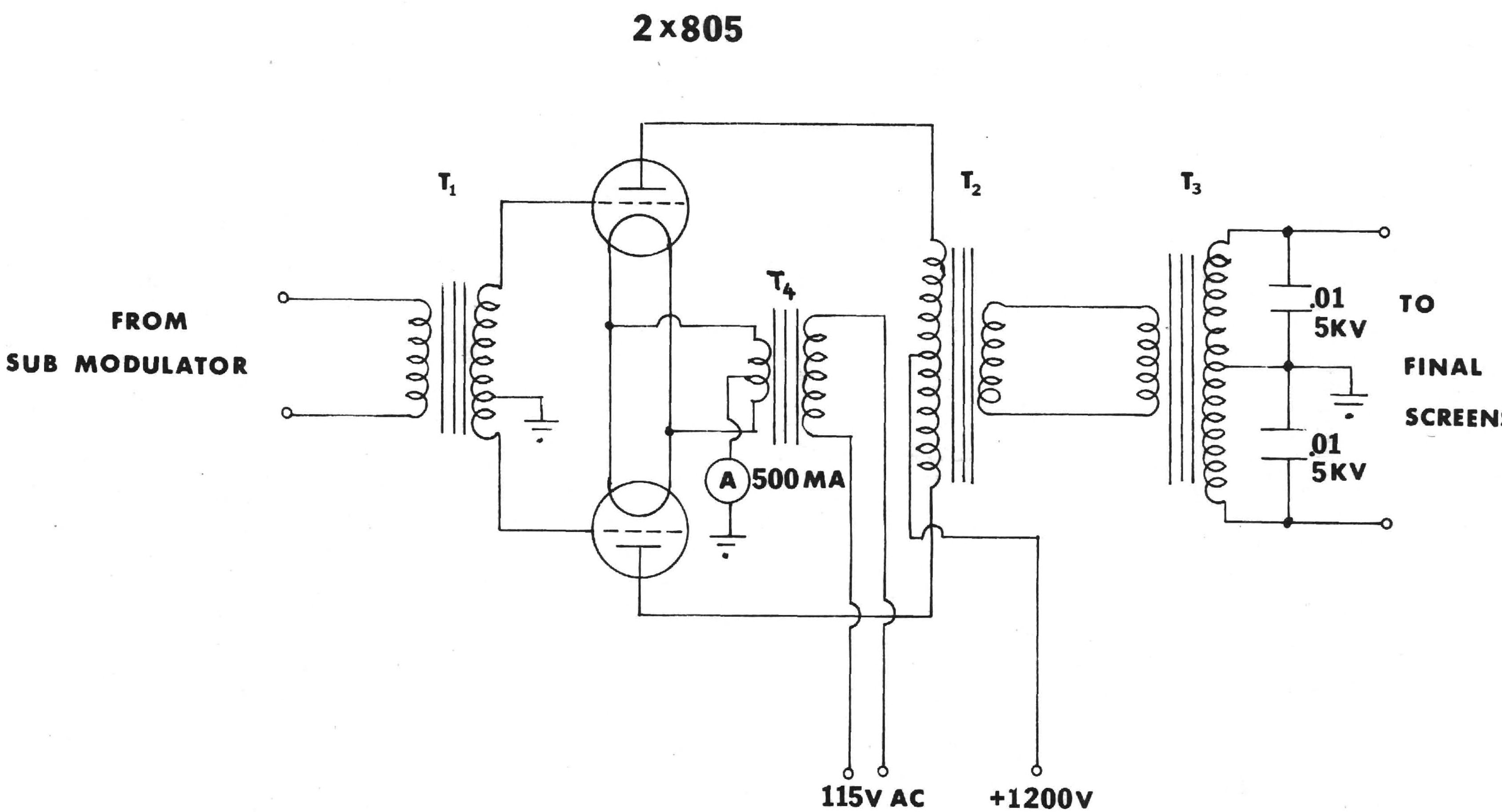

32.5MHz
12AT7
OVEN
50
12K
100
.001
47
18
L_1
.01
47K
1K
18
L_2
4.7K
1K
100
47K
OB2
K
10W
+250V
115VAC
6.3V
5V
807
47
250
.001
.001
20K
100
MA
1K
-150
+600V
RFC_1
.01
C_1
30pf
L_3
100
RFC_2
Z
4-125A
+1200V
RFC_4
.01
C_2
30pf
L_4
L_5
100
32.5MHz
TO FINAL
.004
.004
.004
RFC_3
15K


2x4-1000A
32.5 MHz
FROM EXCITER
L1
L2
50
15
25
15
10
100
150
RFC1
3K
Z
Z
C
Z
Z
RFC2
3K
.004
.004
M
M
A
M
M
M
A
500
RFC3
.001
L3
30
450
32.5 MHz
±360 Hz
TO ANTENNA
TUNER
0-50MA
0-2A
-150V
230VAC
FROM
MODULATOR
4KV

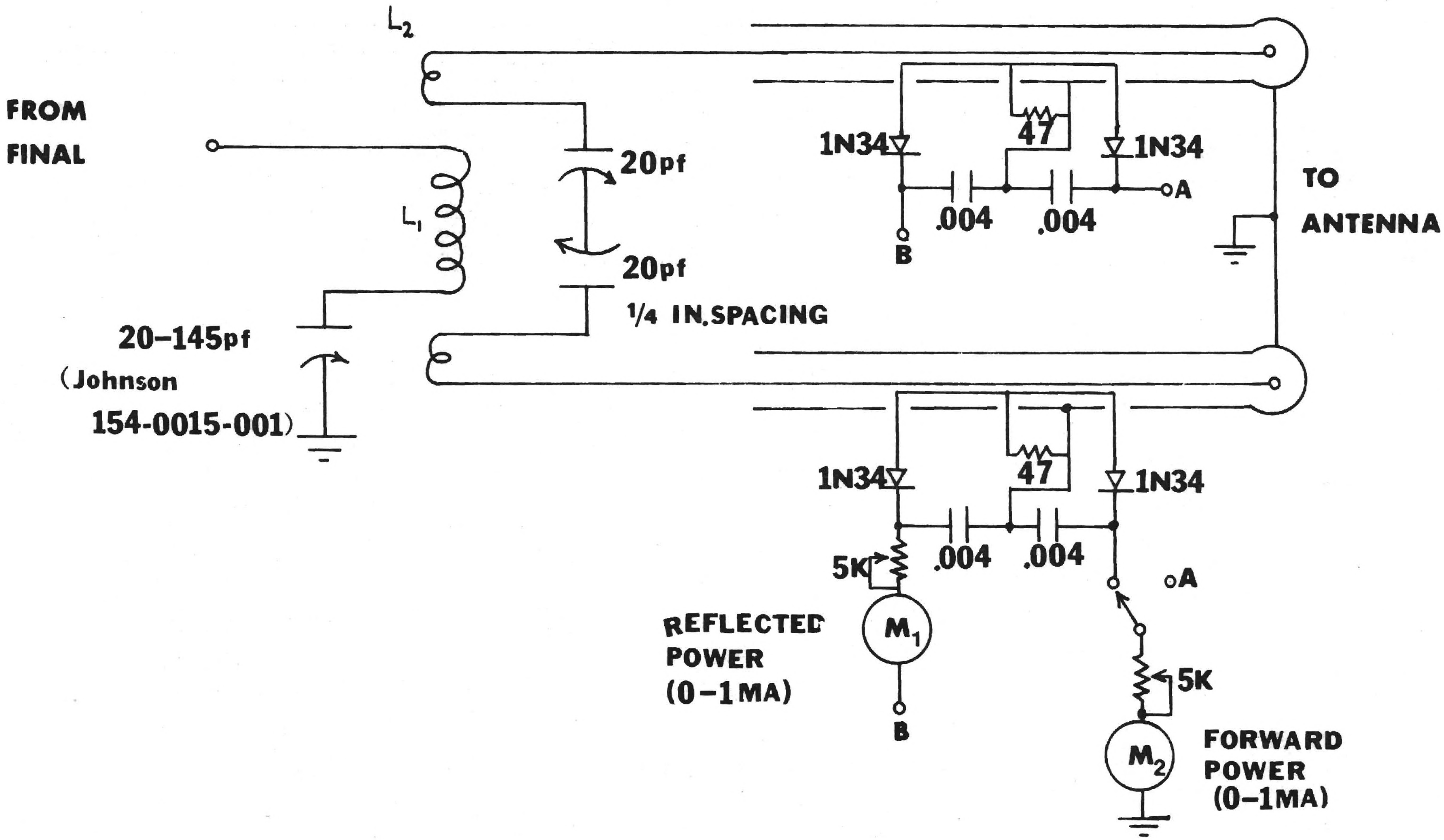
FINAL STAGE



360Hz GENERATOR AND SUB MODULATOR


2×805
T1
T2
T3
T4
FROM
SUB MODULATOR
A
500 MA
.01
5KV
.01
5KV
TO
FINAL
SCREENS
115V AC
+1200V

MODULATOR



L2
FROM
FINAL
L1
20pf
20pf
1/4 IN.SPACING
20–145pf
(Johnson
154-0015-001)
1N34
47
1N34
.004
.004
A
B
TO
ANTENNA
1N34
47
1N34
5K
.004
.004
A
REFLECTED
POWER
(0–1MA)
M1
B
5K
M2
FORWARD
POWER
(0–1MA)

TRANSMITTER

Coil, Choke, and Transformer Data.

EXCITER

L_1	Oscillator anode	15t of 22 AWG enamelled on 1/4" diameter slug tuned former
L_2	Isolator cathode	as for L_1
L_3	Buffer anode	3t of 1/8" OD Cu tubing on 1/12" diameter, 2" long
L_4	Driver anode	5t, as for L_3, 4" long.
L_5	Output coupling	2t, 18 AWG in teflon tubing, 1 1/2" diameter, inserted at HT end of L_4
RFC_1, RFC_3		26 AWG closewound for 1" on 1 1/2" length of 1/2 diameter teflon rod
FRC_2		30 AWG closewound for 2" on 3" length of 1/2 diameter teflon rod

FINAL STAGE

L_1	Input coupling	4t 18 AWG in teflon tubing, inserted between center turns of L_2
L_2	Grid tuning	6t 1/8" OD Cu tubing on 1 1/2" diameter, 2" long
L_3	Final tank	3t 1/4" OD Cu tubing, 2" ID, 2" long
RFC_1, RFC_2		30 AWG closewound for 2" on 3" length of 1/2" diameter teflon rod
RFC_3		30 turns of 18 AWG closewound on 1" diameter ceramic former
Z	Parasitic suppressor	3t 1/8" OD Cu tubing on 1" diameter, 2" long, enclosing 50 Ω 10W carbon resistor

360 Hz GENERATOR AND SUBMODULATOR

C	0.051 mfd
L	3.7 Henry @ 10 ma.
T_1	110 v: 6.3 v @ 0.5 A
T_2	10,000 Ω p/p to 500 Ω, 10 watts.

MODULATOR

T_1	500 Ω to 500 Ω p/p, 10 watts
T_2	630 v/630 v @ 0.5 amp to 230 v
T_3	115 v to 630 v/630 v A 0.5 amp.
T_4	115 v to 10 v @ 8A.

ANTENNA COUPLER

L_1	2T 1/4" OD Cu tubing on 3 1/2" Diameter inserted between halves of L_2
L_2	4T 1/4" OD Cu tubing on 3 1/2" diameter, (2 turns each side of 1 1/2" gap for L_1)

APPENDIX II

THEORY OF RANGE DETERMINATION

THEORY OF RANGE DETERMINATION

Two oscillations, commencing in phase with frequency difference Δf, will be in phase every $1/\Delta f$ seconds. The two signals radiated about 32.5 MHz by the double sideband suppressed carrier transmitter have a Δf of 720 Hz, and will therefore be in phase every 1388.8 microseconds. This places an upper limit on the path difference R_{MAX} for range measurement of 1388.88 x c, where c is the velocity of light; thus R_{MAX} = 416.350 km.

Each echo consists of two doppler shifted skywaves. When combined individually with the appropriate groundwave sideband at the receiving site, each skywave prodes a doppler beat waveform whose relative phase is that of the skywave. If the transmitting and receiving sites coincide (as in a conventional radar) the phase difference ϕ between the output from the 1120 Hz and 1840 Hz channels of receiver 2 depends on the range R such that

$$\phi = \frac{4\pi R\Delta f}{c}$$

i.e.

$$R = \frac{1}{4\pi}\frac{c}{\Delta f}$$

Again, only the phase difference is measured at the receiving site. The appropriate echo range is subsequently computed on campus, using a computer program which solves for the echo position on the minimum path ellipse specified by the measured ϕ and the transmit/receive system geometry. Details of the algorithm used are contained in Appendix IIA of the Georgia Tech Radio Meteor Wind Facility Computer Program Library (Volume 3 of this series).

THE GEORGIA TECH - TECHNOLOGY PARK/ATLANTA RADIO METEOR WIND FACILITY RECEIVING AND DATA RECORDING EQUIPMENT

THE GEORGIA TECH - TECHNOLOGY PARK/ATLANTA RADIO METEOR WIND FACILITY RECEIVING AND DATA RECORDING SITE.

An all sky, continuous wave radio meteor wind facility has been installed in Atlanta by the Georgia Institute of Technology under National Science Foundation sponsorship. A double sideband suppressed carrier CW transmitter, operating on 32.5 MHz $\pm$ 360 Hz, with an RMS output of 2 KW, has been installed on the Georgia Tech Campus, and a receiving site established at Technology Park/Atlanta, 27 kilometers northeast of the campus.

INTRODUCTION

The Georgia Tech Radio Meteor Wind Facility was originally conceived in 1970 as a single receiving station, continuous wave system, with adequate sensitivity to record 1000 useful echoes per day, and range and echo arrival angle accuracy such that the height of each echo was specified to $\pm$ 2 km. The system in use since 1960 at Adelaide, Australia (Weiss and Elford, 1963; Roper, 1965) satisfied these criteria, and was used as a starting point for the design of the Georgia Tech system.

Two significant changes were deemed essential. First the system must record echoes on magnetic tape, and not on film, and second, an alternative echo ranging system was desirable, to eliminate the companion pulse transmitter as used at Adelaide.

The first criterion was met by the design of an analog to digital hardware interface between the receiver outputs and a Kennedy Model 1610 incremental tape recorder. The second, by using a double sideband suppressed carrier continuous wave transmitter, and the range finding method detailed by Spizzichino [1972].

Although characterized by high echo rate, and elimination of the necessity for maintenance of RF phase through the system (the phase relationship between groundwave reference and skywave echo is established at each receiving antenna), the CW method of meteor trail drift measurement suffers from one inconvenience, and one downright nuisance. The inconvenience is in the necessity for separation of the transmitting and receiving sites -- the nuisance is the presence of echoes from aircraft. Being well within the holding pattern of aircraft approaching Atlanta International Airport, up to 100% of all useable meteor echoes can be lost at times of peak airport use. In particular, the Georgia Tech facility useable meteor echo recording rate drops to practically zero between 1100 and 1400 hours each day -- this in addition to the normal diurnal meteor flux variation with maximum at 0600 hours, and minimum at 1800 hours. Preliminary estimates made since going into routine operation in July, 1974, indicate that approximately 50% of all echoes are contaminated by the presence of simultaneous aircraft reflections. Aircraft interference notwithstanding, an average of 300 useable meteor echoes a day are recorded.

The receiving site is located at Technology Park/Atlanta, 27 km northeast of the transmitter. The receiving and data recording equipment is housed in a 6' rack in a trailer at the site. Both heating and air conditioning are provided, keeping the trailer always at a temperature between 65 and 85° F. Figure 1 is a block diagram of the receiving/recording equipment.

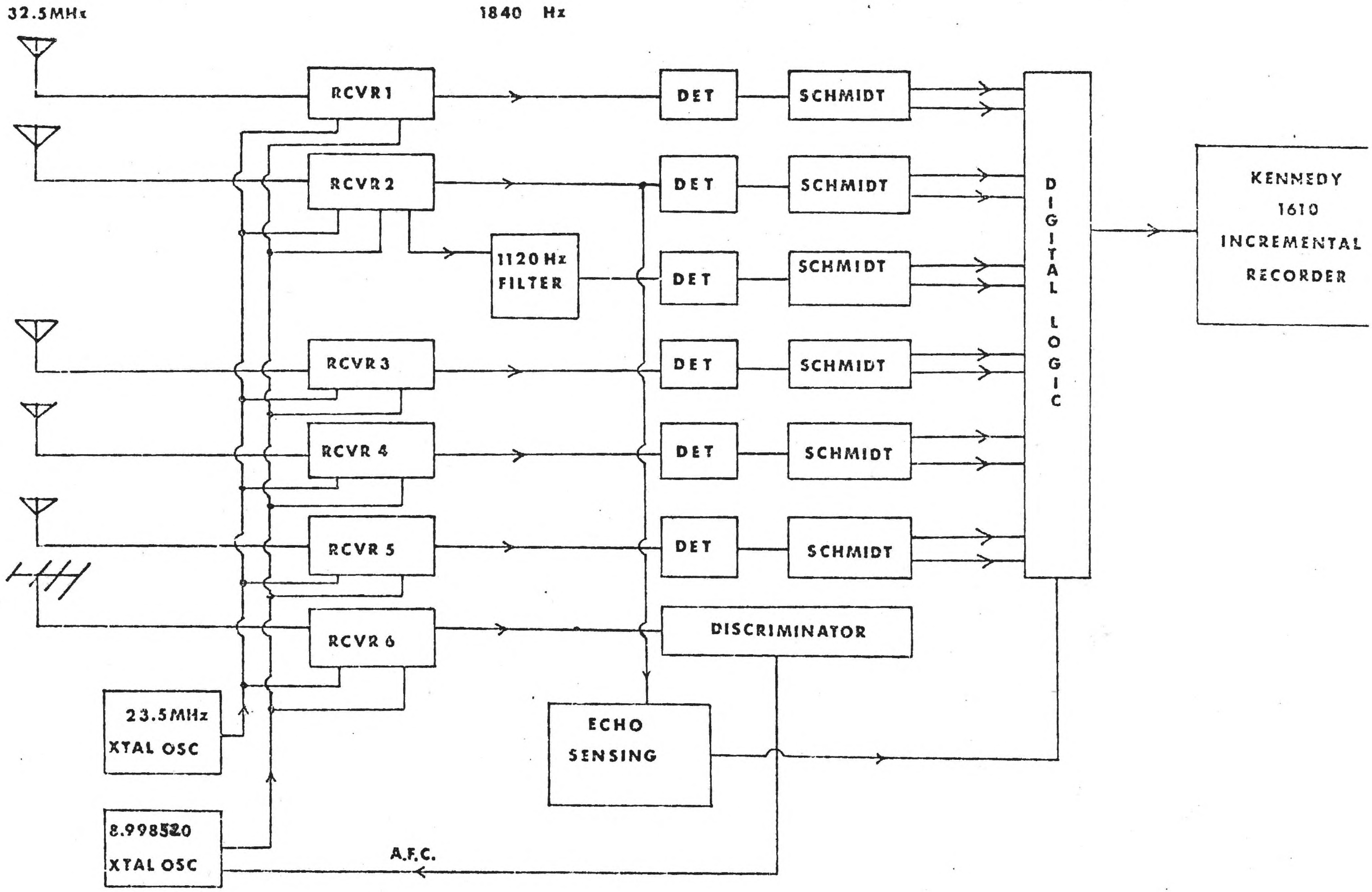

32.5MHz
1840 Hz
RCVR1
RCVR2
RCVR3
RCVR 4
RCVR 5
RCVR 6
DET
DET
DET
DET
DET
DET
SCHMIDT
SCHMIDT
SCHMIDT
SCHMIDT
SCHMIDT
SCHMIDT
1120 Hz FILTER
DIGITAL LOGIC
KENNEDY 1610 INCREMENTAL RECORDER
DISCRIMINATOR
ECHO SENSING
23.5MHz XTAL OSC
8.998520 XTAL OSC
A.F.C.

Figure 1.

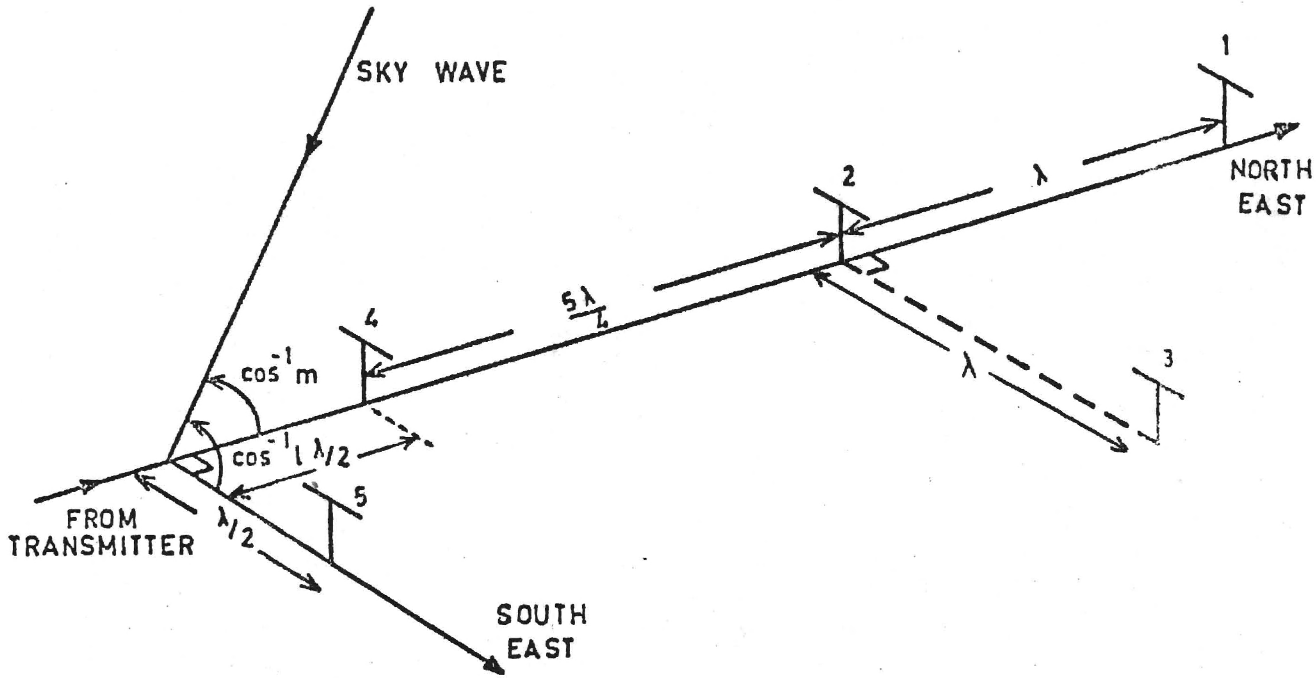


FIGURE 2 - LAYOUT OF DIRECTION FINDING AERIALS

THE ANTENNAE

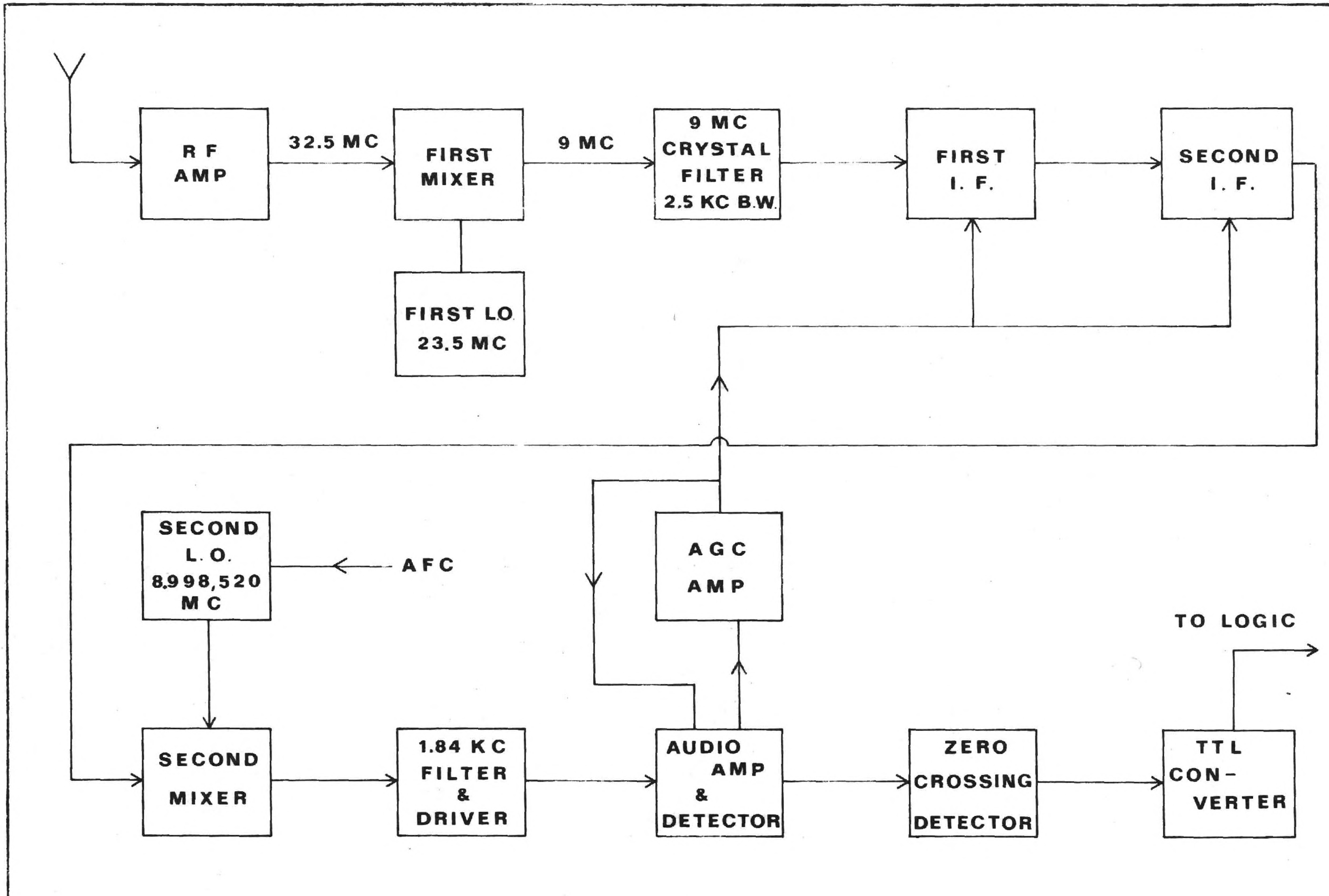
The direction finding system is similar to that employed at Adelaide. Separation and terrain between transmitter and receivers are such that each $\lambda/2$ dipole antenna, $\lambda/4$ above ground, feeds a ground wave signal of 10 microvolts (across 75 ohms) to the input of its associated receiver. Antennae 1, 2 and 3 (Figure 2) form an azimuth/elevation determining set, with reference phase established by the groundwave. Spacing and orientation of these antennae is such that the groundwave has the same phase at each antennae. Antennae 4 and 5 are used to resolve ambiguities in echo arrival angle determination; again the groundwave establishes the reference phase at each of these antennae. Details of the echo arrival angle determination are contained in PRØGRAM METEØR in the Georgia Tech Radio Meteor Wind Facility Computer Program Library (volume 3 of this series).

THE RECEIVERS

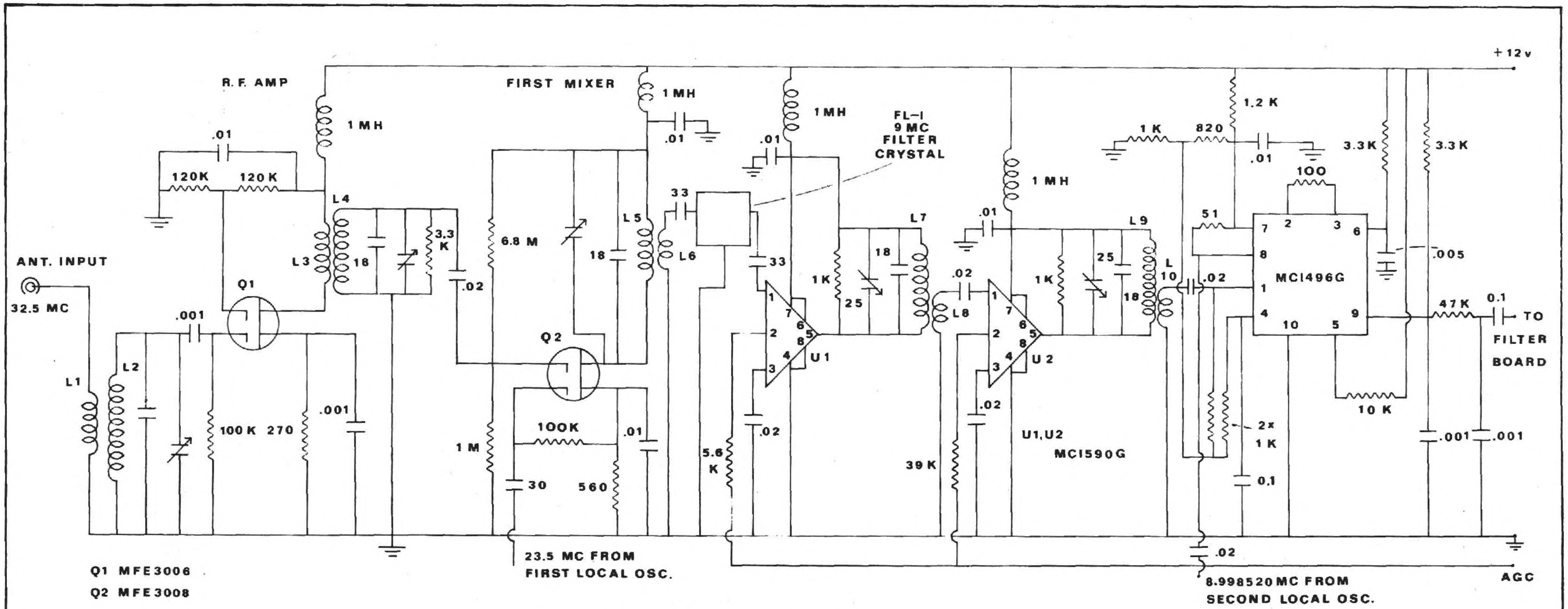
1. RF/IF circuits

Each of the direction finding antennae feeds a separate receiver.

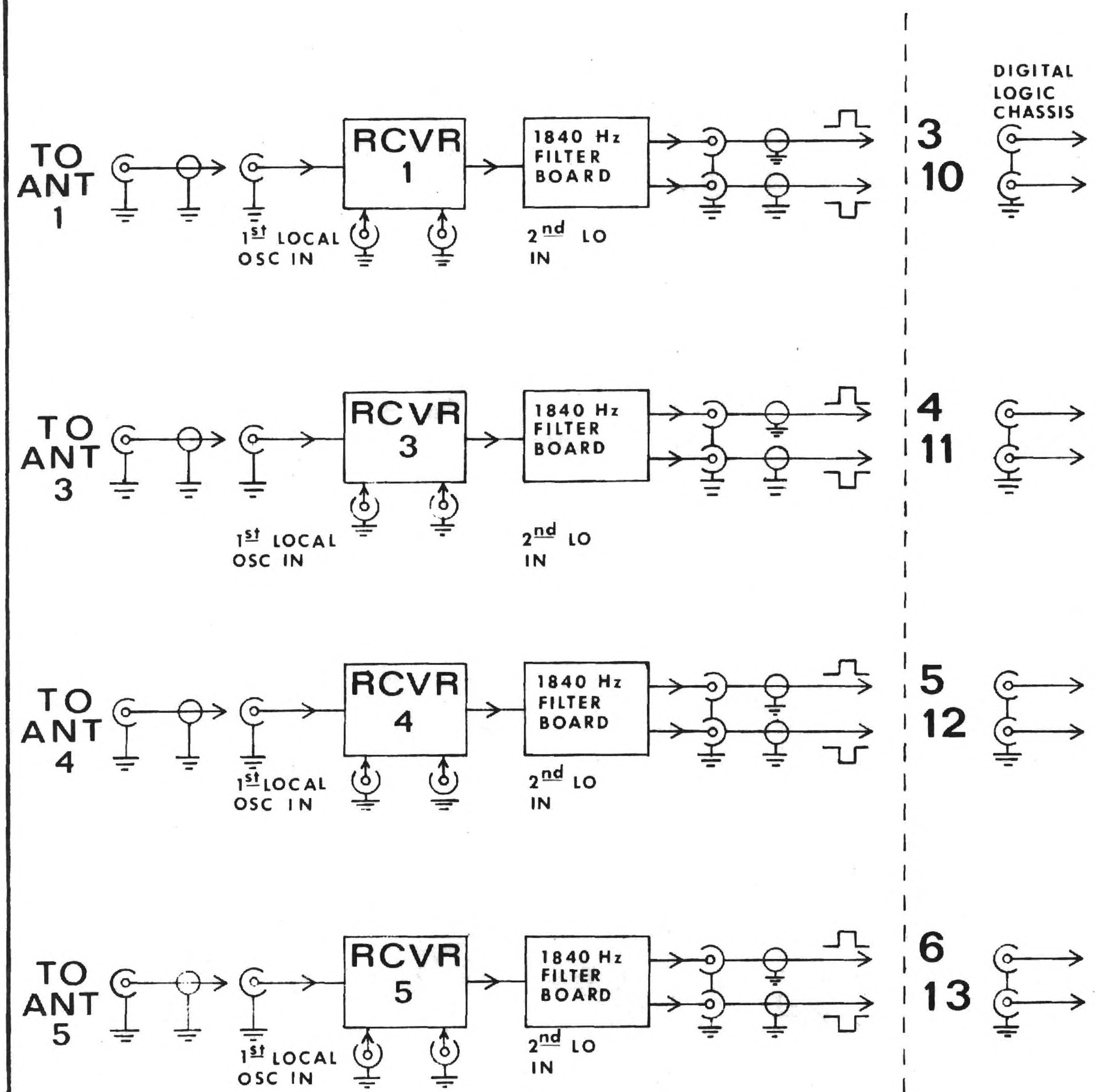
Each receiver has a 2N3006 FET dual gate 32.5 MHz RF amplifier, followed by a dual gate 2N3008 FET mixer with a 9 MHz difference frequency output. Mixer injection is provided by a common 23.5 MHz crystal controlled oscillator (see First Local Oscillator). A 2.5 KHz bandwidth crystal filter (type KVG-XF9A, available from Spectrum International) provides selectivity ahead of 2 AGC controlled MC1590G IF amplifier stages. These in turn feed an MC1496 mixer, which produces two difference frequencies - 1840 Hz corresponding to the upper transmitted sideband, and 1120 Hz corresponding to the lower sideband. Mixer injection is provided by a common 8.998520 KHz



RECEIVER BLOCK DIAGRAM

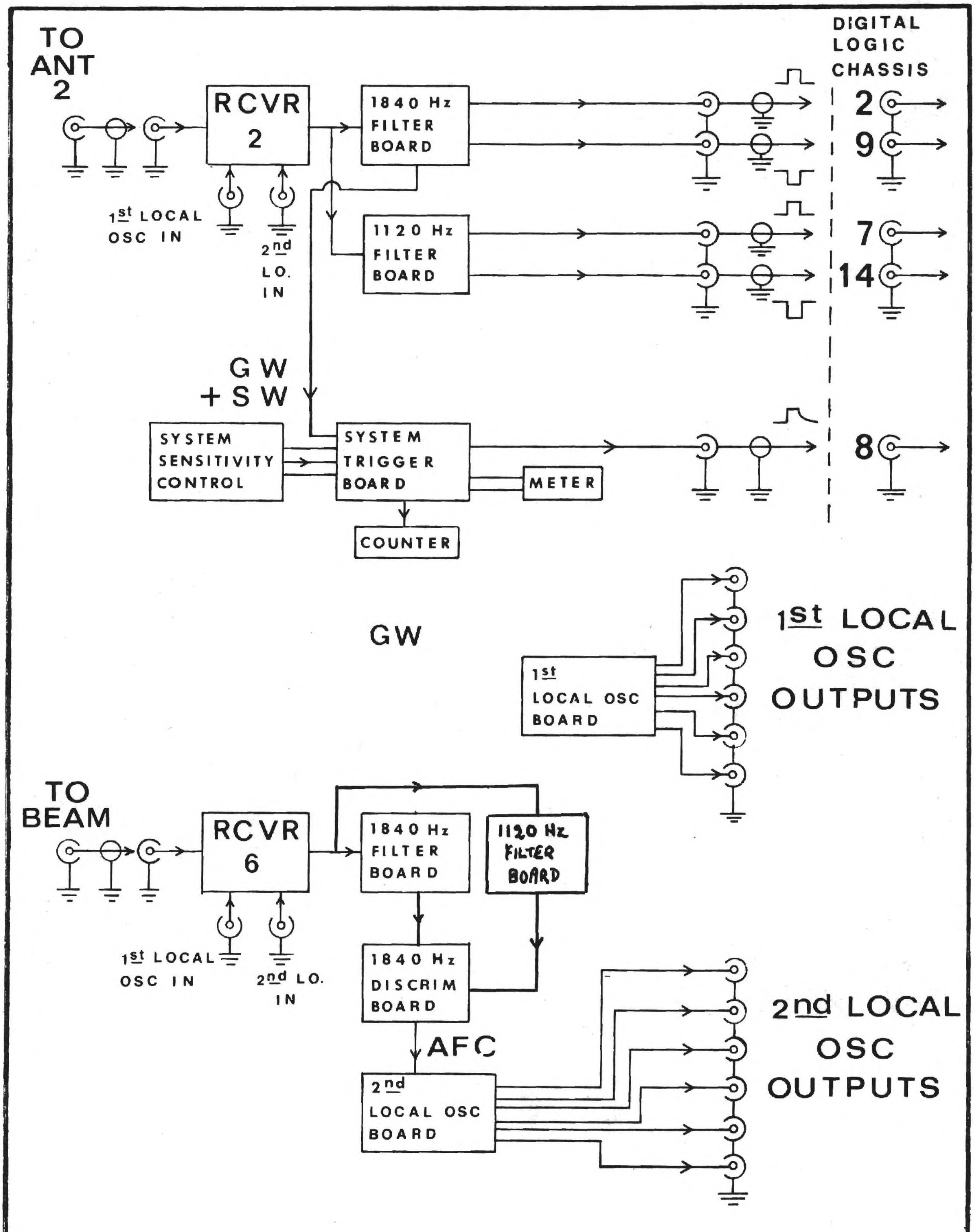


RECEIVER RF/IF CIRCUIT

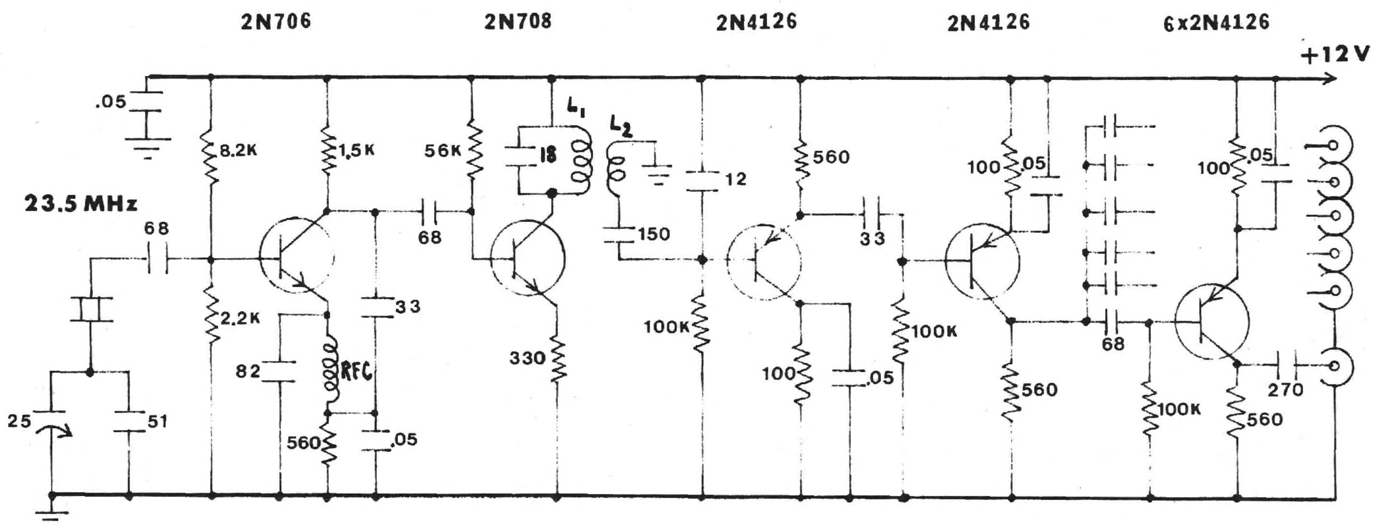


BLOCK DIAGRAM-

RECEIVERS 1,3,4, AND 5.



BLOCK DIAGRAM-RECEIVERS 2 AND 6



1st LOCAL OSCILLATOR

crystal oscillator (see Second Local Oscillator).

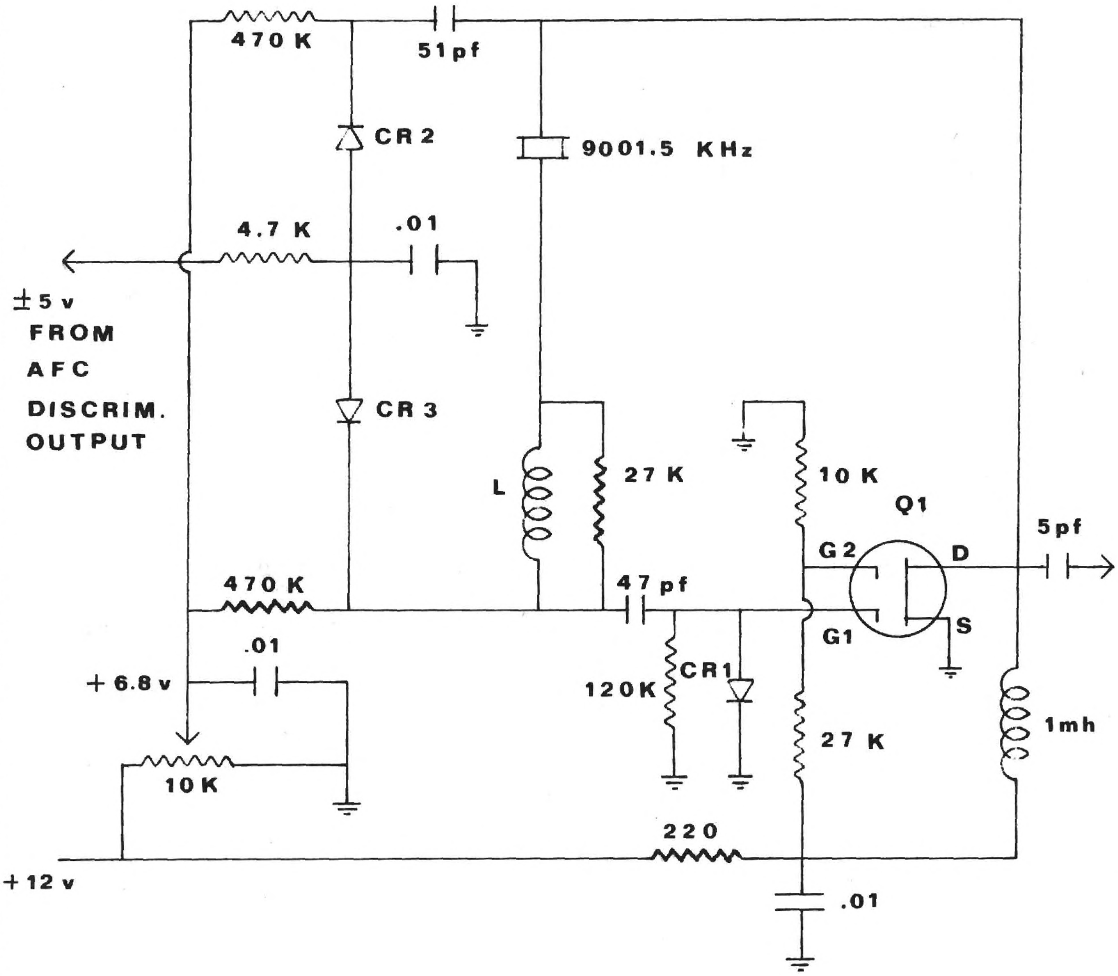
FIRST LOCAL OSCILLATOR.

A conventional colpitts crystal controlled oscillator on 23.5 MHz, using a 2N706, is followed by a 2N708-2N4126-2N4126 buffer/amplifier, which drives the bases of 6 2N4126's. The output of each of these isolating stages is fed individually to the first mixer of each receiver.

SECOND LOCAL OSCILLATOR

The second local oscillator has its frequency controlled by the voltage output from the automatic frequency control discriminator. The frequency determining element is a quartz crystal, in a VXO (variable crystal oscillator) circuit (De Maw, 1972). A high Q toroidal inductor, suitably resistively damped, is placed in series with the crystal, and the combination tuned by two voltage variable diodes, Motorola type MV1404. The circuit requires a high gain low input capacitance amplifier - the dual gate 40673, with one gate as an active element, the other biased to +3 volts, is ideal. Two 470 K ohm resistors are used as bias isolation elements, with the common diode anodes RF grounded by a 0.01 ufd capacitor. The 4.7K/0.01 filter ensures that no RF appears on the AFC control line. The 1N914 diode from gate to ground limits positive going excursions of the gate signal, minimizing the effective gate input capacitance (thereby increasing the upper frequency shift attainable) and stabilizing the operating point.

A "back to back" tuning diode configuration is employed; the circuit requires a center tapped capacitance, but series diodes would require voltage dividing resistors, and cause severe loading of the other frequency



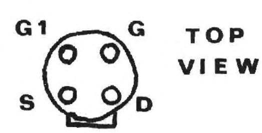
VXO CIRCUIT $8998.520 {}^{+2.3}_{-3.6}$ KHz

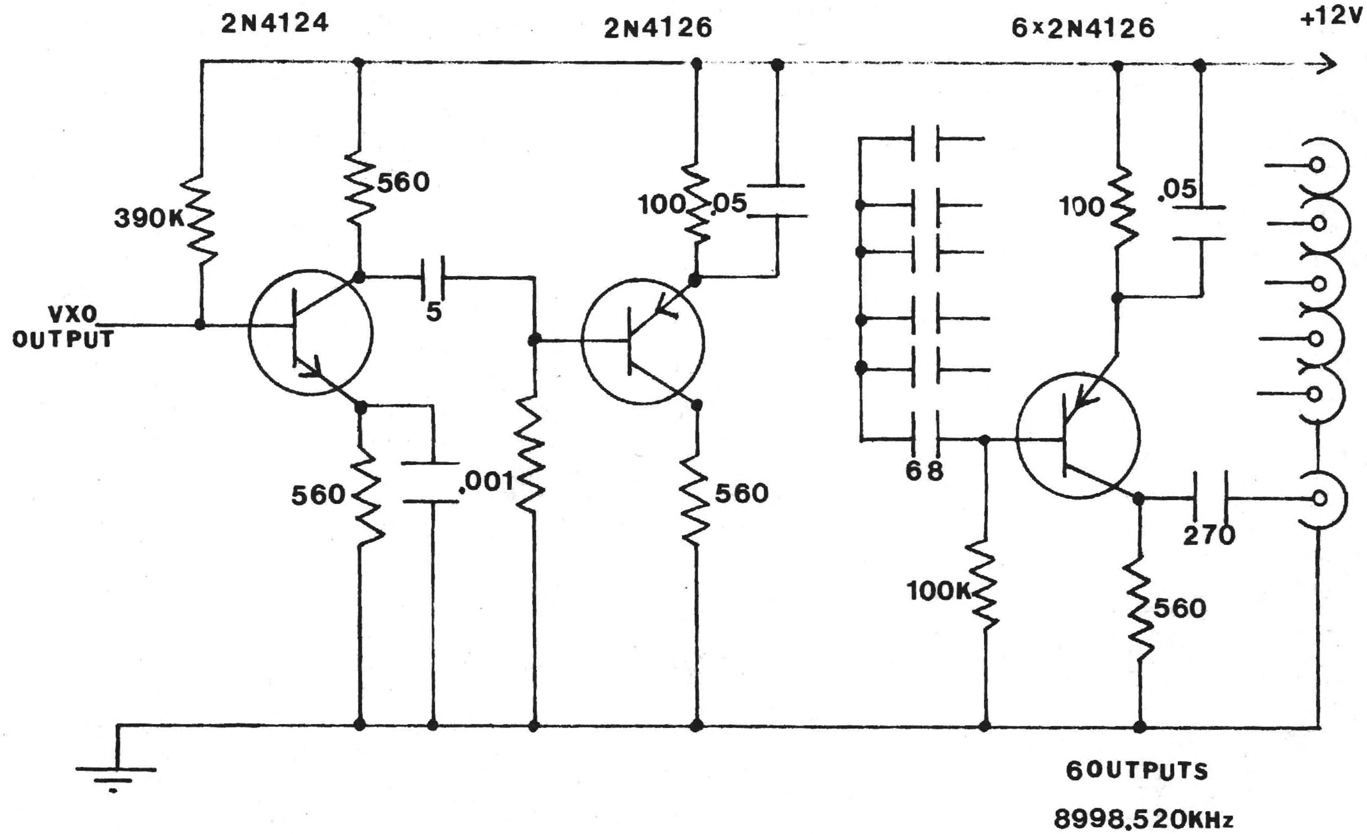
CRI IN9I4

CR2-3 MVI404 VARICAP

L 52T, No 22, AMIDON, T-50-6 TOROID

QI 40673





VXO AMPLIFIER

determining components as diode capacitance varied in sympathy with the RF voltage across them (Orr, 1972).

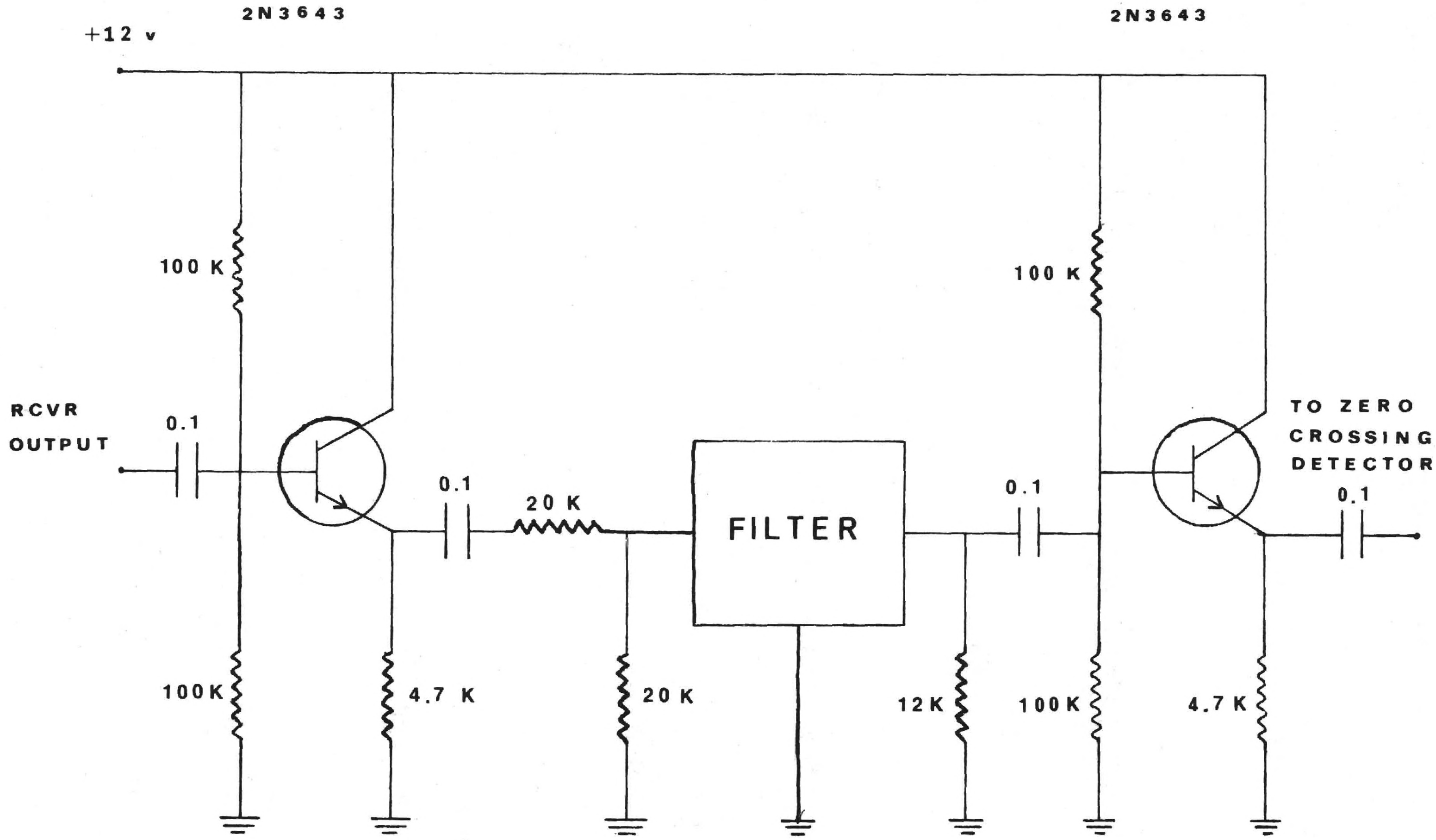
The AFC discriminator produces zero volts output with an 1840 Hz input (or in the absence of a coherent signal in the AFC filter passband). The inductance of the toriod in series with the crystal has been trimmed (to within the nearest turn) so that the crystal tunes to 8998.520 KHz with each varicap diode having an effectice capacitance of 33 pf. This zero AFC output bias is selected by the 10 K trimpot, and is approximately 6.8 volts.

Note that this voltage is considerably higher than that which would be inferred from the published curves for the MV1404. This discrepancy is due to the presence of an RF voltage of some 6 v peak to peak across each diode in the oscillator circuit - manufacturer's calibration curves apply to small signal applications where the RF voltage impressed on the diode is much less than the bias voltage. As the AFC control voltage swings from -5 volts to +5 volts, corresponding to an AFC input frequency change of 1876 Hz to 1804 Hz, each varicap covers the range 17 pf to 140 pf, shifting the open loop VXO frequency from 9000.830 KHz to 8994.847 KHz. This represents an open loop AFC "gain" G of

$$\frac{9000.830 \text{ KHz} - 8994.847 \text{ KHz}}{1876 \text{ Hz} - 1804 \text{ Hz}} = 83$$

Thus, in the closed loop AFC configuration, an "input" drift of 83 Hz results in an output signal frequency shift of 1 Hz.

The capture range of the loop is $\pm$ 1250 Hz, (determined by the AFC sweep generator and receiver intermediate frequency bandpass filter). Thus any captured signal will be "pulled" to within $\pm$ 15 Hz of the center



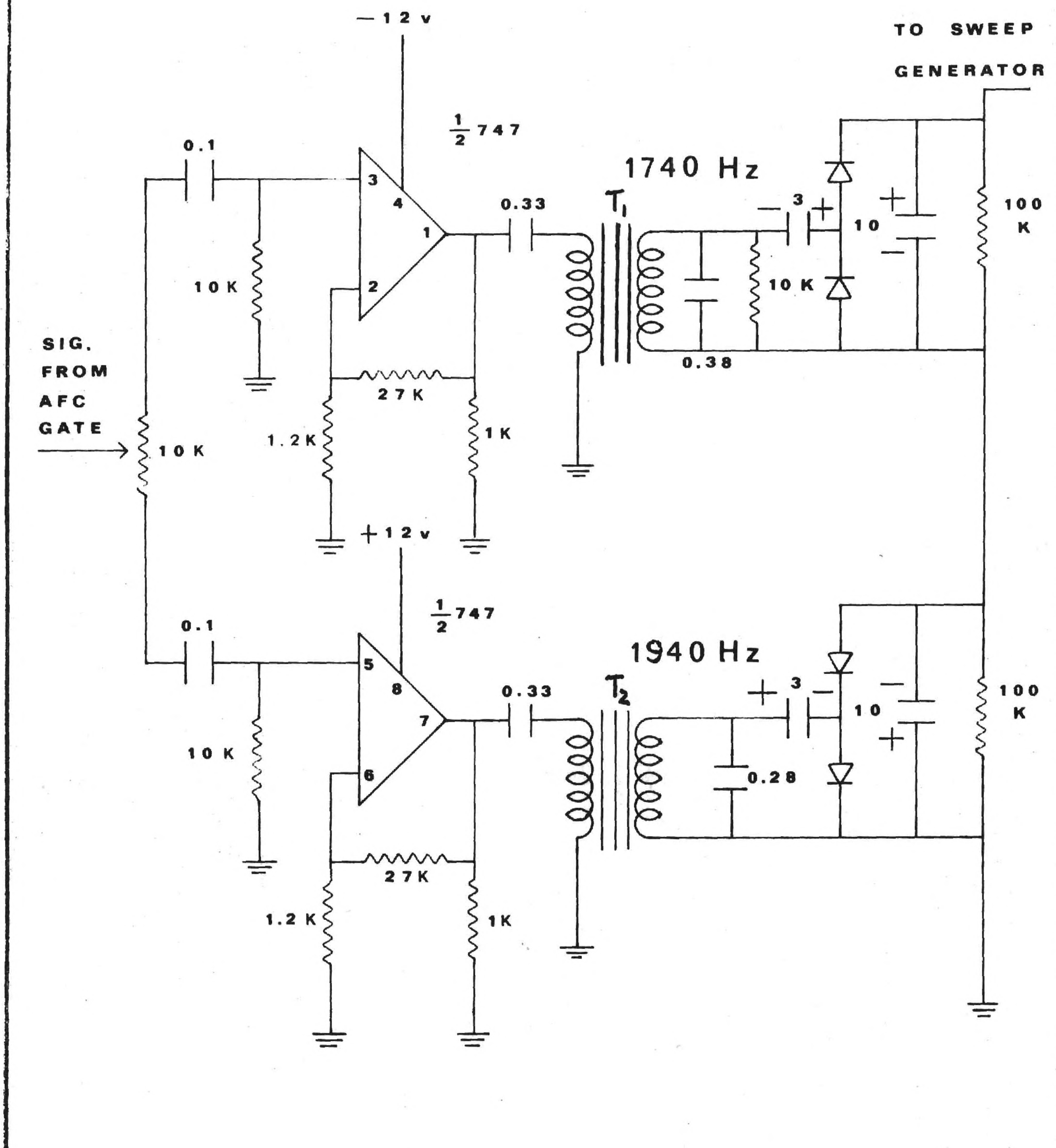
FILTER BOARD (8of)

of the 2nd IF passband. In routine operation, the 2nd IF frequency normally lies within ± 3 Hz of passband center.

To ensure adequate isolation of the second local oscillator outputs, the VXO signal is amplified by a 2N4124 - 2N4126 buffer/amplifier, and then applied to the bases of 6 2N4126's. The output of each of these isolating stages is fed individually to the second mixer of each respective receiver.

THE SIDEBAND FILTERS

The output of the second mixer of each receiver consists of two frequencies - 1840 Hz corresponding to the upper transmitted sideband groundwave, and 1120 Hz corresponding to the lower transmitted sideband groundwave. The skywave reflected from a drifting meteor trail will be doppler shifted a maximum 30 Hz (corresponding to a line of sight drift of approximately 140 m/sec). Thus the desired information appropriate to each sideband is contained in a bandwidth of ± 30 Hz. Every receiver is followed by a plug in module containing a 2N3643 emitter follower input stage, a TT Electronics K17 miniature bandpass filter, centered on 1840 Hz, with a bandwidth of ± 50 Hz, and a 2N3643 emitter follower output stage. The emitter followers are designed to match both the input and output impedances of the filter, to preserve optimum bandpass. In addition, receivers 2 and 6 each have a similar plug in unit incorporating an 1120 ± 50 Hz filter. That from receiver 2 provides lower transmitted/skywave sideband output for the echo range measurement; that from receiver 6, the lower trasmitted sideband signal for the AFC gating circuit.



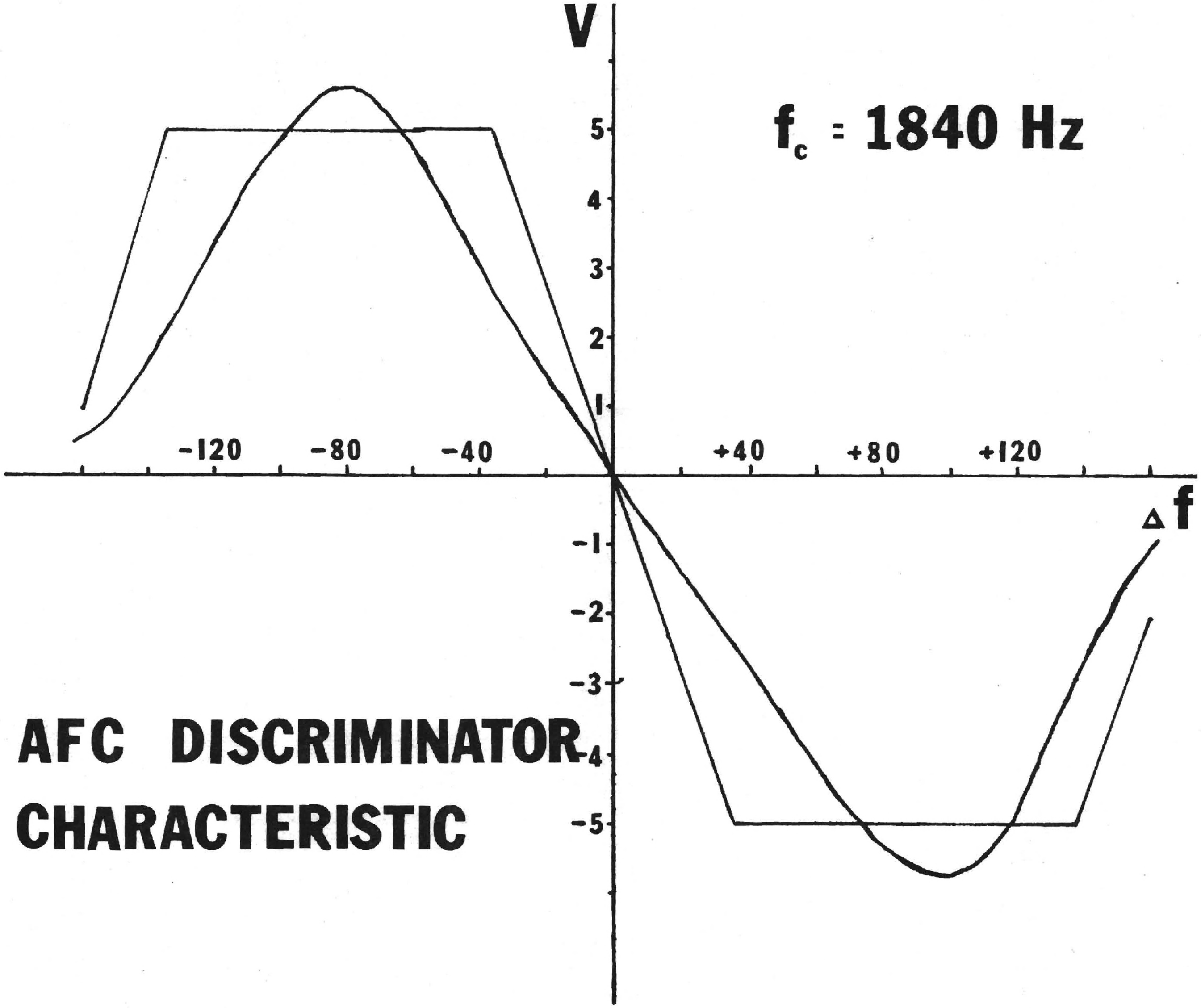
AFC DISCRIMINATOR

THE AUTOMATIC FREQUENCY CONTROL DISCRIMINATOR

The circuits described in the sections "The AFC Discriminator" through "The Echo Sensing Unit" are the result of considerable R and D. For this reason, there is not always a one to one correspondence between IC type numbers in the text and in the circuit diagrams. In particular, type nos. 558 and 747 used on prototype boards have all been replaced by MC1458 14 pin DIP's, even though not necessarily detailed as such in text or circuits. Either 8 pin or 14 pin connections appear in circuits.

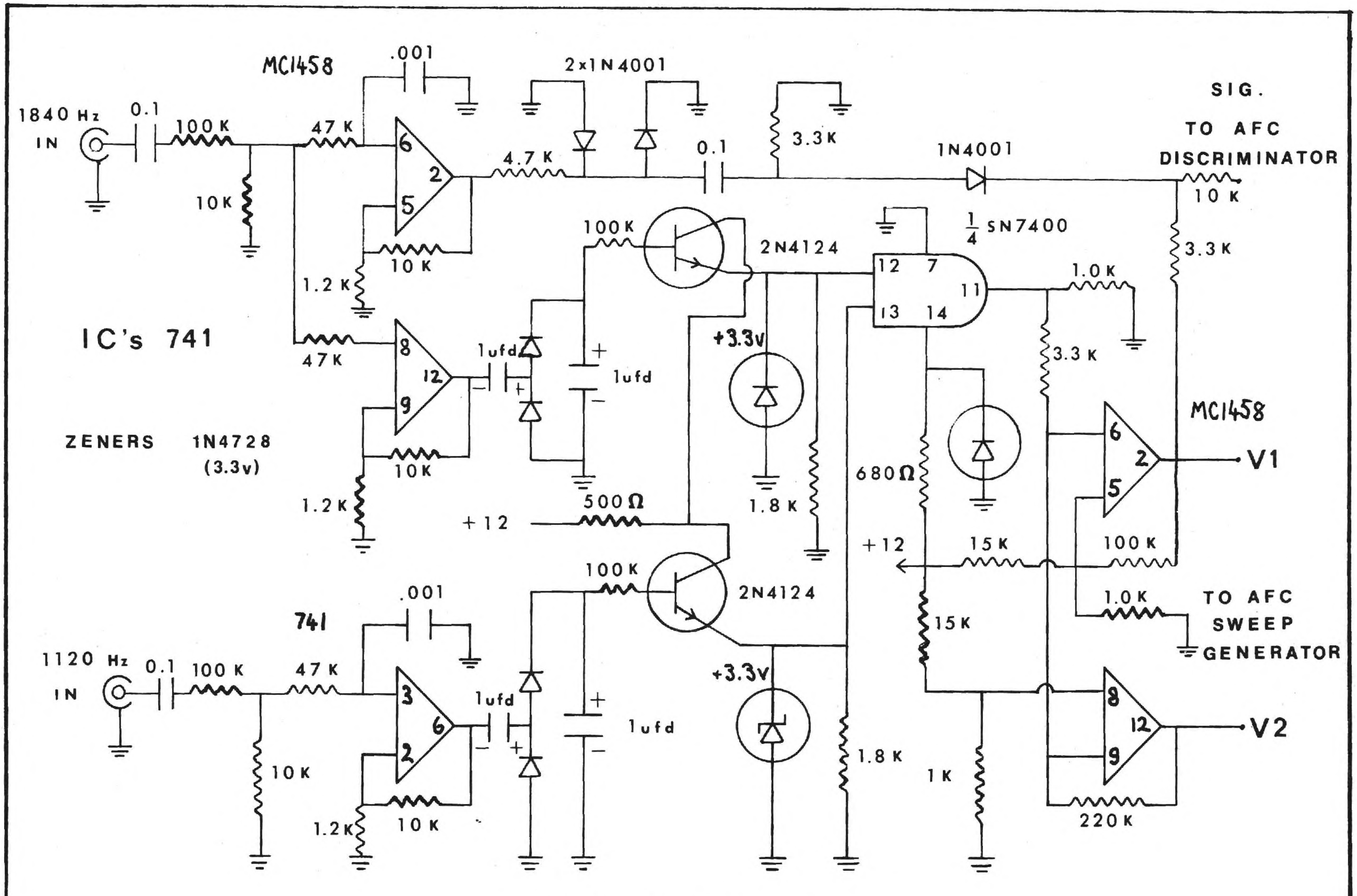
In order that the full signal to noise potential of the CW meteor radar method can be realized, 100 Hz wide ($\pm$ 50 Hz) filters are used in the 1840 Hz and 1120 Hz signal paths before digitization. This places severe limits on the frequency stability of the transmitter (controlled by an oven mounted quartz crystal on 32.500 MHz) and the receiver first (23.500 MHz) and second (8.99852 MHz) local oscillators. Both these oscillators are crystal controlled, but the second crystal is "rubbered" in a VXO circuit (see Second Local Oscillator) to provide automatic frequency control, which keeps the upper and lower sideband signals appearing in the receiver IF amplifiers (9 MHz $\pm$ 1.25 KHz) within $\pm$ 15 Hz of the centers of the respective 100 Hz bandwidth filters after the second mixers.

Normal operation corresponds to the "locked" mode of the AFC gating circuit. In this condition, the transmitted upper sideband signal appears as an 1840 Hz signal out of the AFC ground wave receiver 6. This signal is gated to the input of the AFC discriminator where it is split and applied to two separate frequency sensitive detectors, one tuned to 1940 Hz, the other to 1740 Hz. The DC outputs of these detectors are connected in antiphase. The discriminator balance potentiometer in the amplifier input cir-

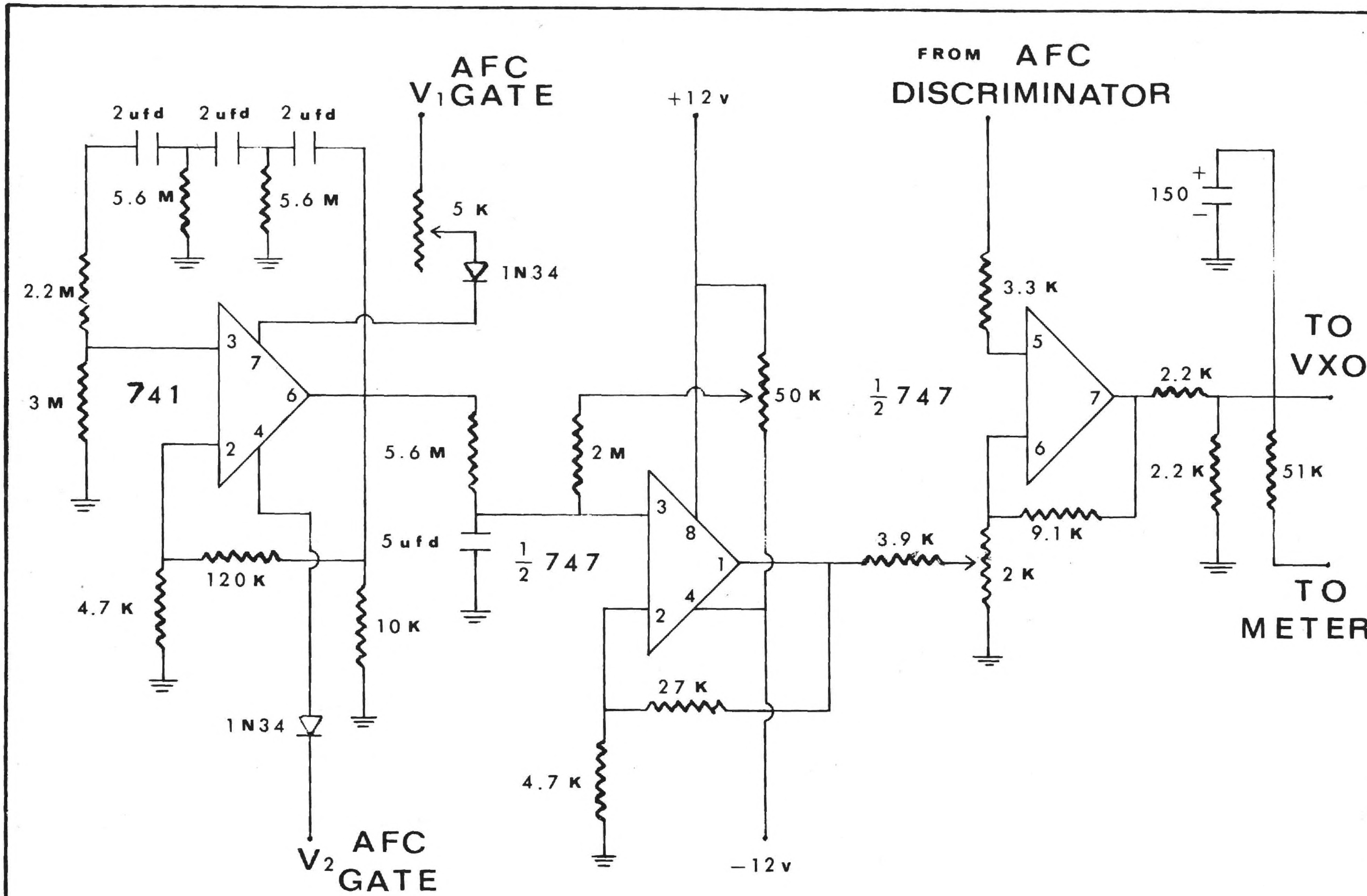


AFC DISCRIMINATOR CHARACTERISTIC

cuits is adjusted so that, with an 1840 Hz input signal, the DC output from the discriminator is zero. With a 1740 Hz input signal, the DC output is +5V; with 1940 Hz in. - 5V. The AFC output potential is amplified and is monitored by the high impedence ½ 558 (U2B) voltmeter, and displayed via a center zero meter of the front panel. The AFC amplified output is also fed to the varicap diodes whose capacitance determines the output frequency of the Second Local Oscillator.


MC1458
.001
2x1N4001
SIG.
TO AFC
DISCRIMINATOR
1840 Hz
IN
0.1
100 K
47 K
4.7 K
0.1
3.3 K
1N4001
10 K
10 K
1/4 SN7400
2N4124
100 K
3.3 K
1.2 K
10 K
12 7
11
13 14
1.0 K
IC's 741
47 K
1ufd
1ufd
+3.3v
3.3 K
MC1458
ZENERS 1N4728
(3.3v)
10 K
680Ω
V1
1.2 K
1.8 K
+12
500Ω
+12
15 K
100 K
100 K
2N4124
1.0 K
TO AFC
SWEEP
GENERATOR
.001
741
15 K
1120 Hz
IN
0.1
100 K
47 K
1ufd
1ufd
+3.3v
V2
10 K
1.8 K
1 K
1.2 K
10 K
220 K

AFC GATING



AFC SWEEP GENERATOR

THE AUTOMATIC FREQUENCY CONTROL GATING AND SWEEP CIRCUITS

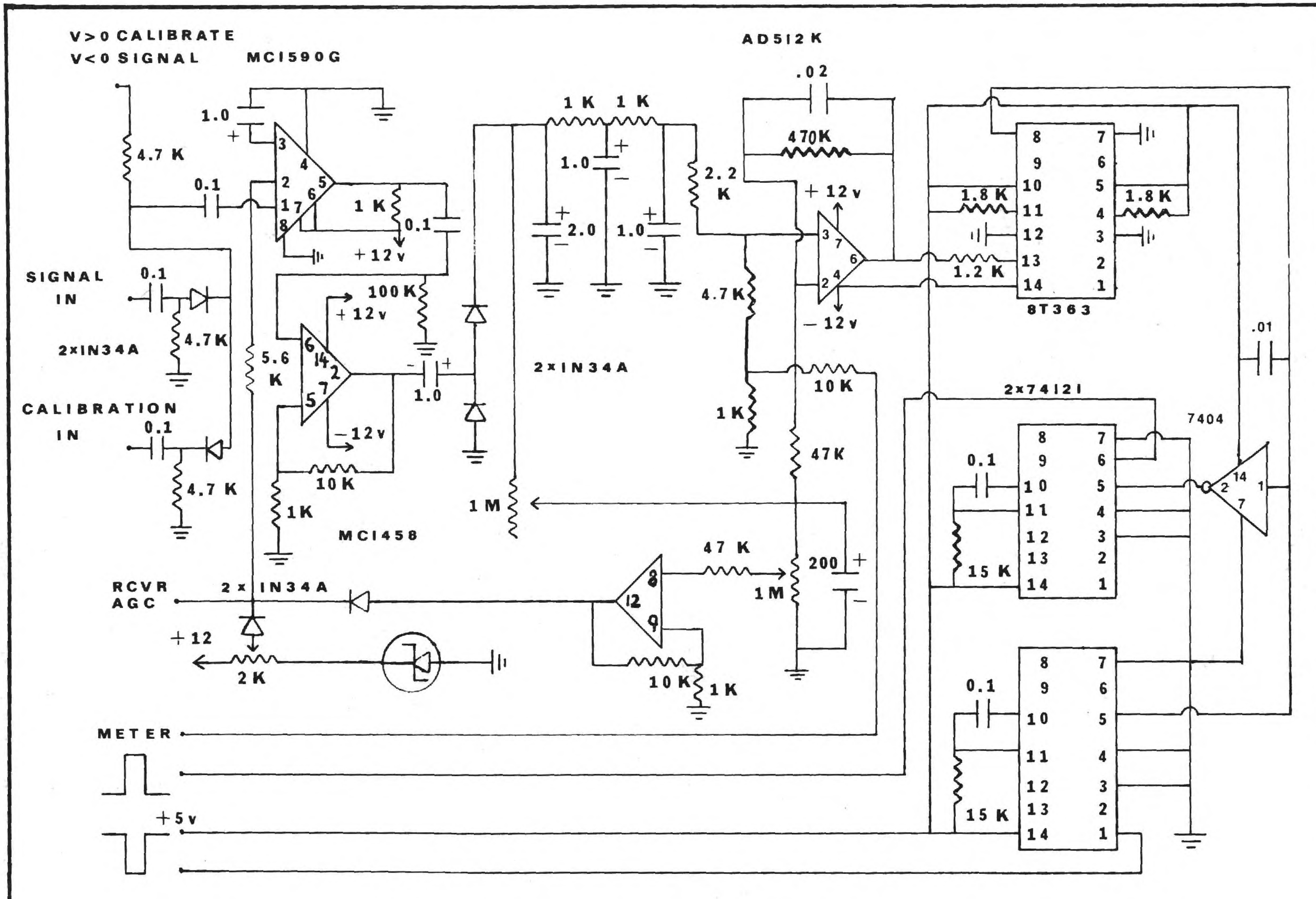
The receiver bandwidths are 100 Hz - thus, if either transmitter or receiving site should be temporarily "off the air", resumption of operation may result in the groundwave signals appearing outside the receiver passbands, and therefore outside the capture range of the automatic frequency discriminator. For example, if the transmitter should go off the air for sufficient time for its crystal oven to drop from 75° C to room temperature, then, when power is reapplied, its output frequencies (dsbsc) will be 400 Hz low,well outside the receiver 2nd IF passbands. Similarly, the receiver local oscillator frequencies can be as much as 500 Hz off if the van temperature should change significantly. As long as the AFC circuit remains in lock, such changes in transmitter or local oscillator frequencies would result in only a few hertz change in the frequencies of the signals in the 1840 Hz (or 1120 Hz) receiver bandpass filters. Out of lock, such changes result in signals which may take hours to fall within the appropriate $\pm$ 50 Hz limits, and be recaptured again by the AFC discriminator.

To cope with this circumstance, the AFC Gating and Sweep circuits have been devised. If the input signal to the AFC circuit disappears (or is not present when the receivers are reenergized after a temporary power failure), the NAND gate IC1 (1/4 7400) output goes high, switching the outputs V1 and V2 of gates U_{3A} and U_{3B} (dual 741) 10V positive and negative respectively. This open circuits the diode switch in the 1840 Hz input line to the AFC discriminator, and applies $\pm$ 10 V through the protective diodes CR1 and CR2 (ea IN34A) to U1, a 741 sweep oscillator, which produces a 1 cycle in 10 seconds square wave. Upon integration and amplification by U2A (1/2 558), ± 2V of triangular waveform is fed to the inverting input of the AFC amplifier. This sweeps the receiver 2nd local oscillator ± 1250 Hz about its nominal frequency of 8998.520 KHz, thus effectively sweeping the bandwidth of the 9 MHz IF. This sweep will be disabled, and control returned to the AFC discriminator, only when simultaneous output signals in both the 1840 Hz and 1120 Hz IFs are present. This ensures that the AFC circuit neither locks onto the wrong transmitted sideband, nor any other carrier which may happen to be within the receiver passband, but will lock only onto two simultaneously present carriers 720 Hz apart.

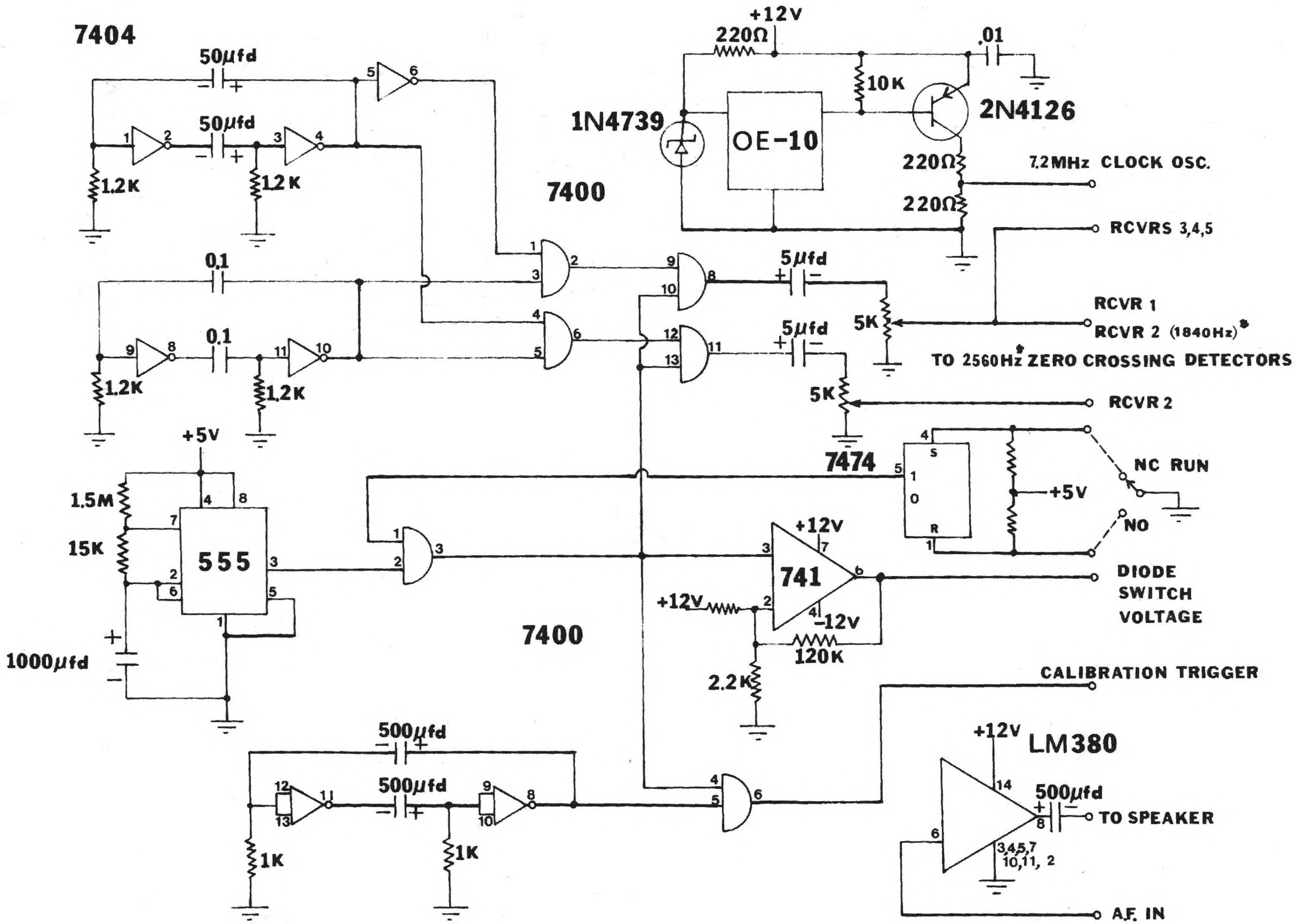
THE DOPPLER ZERO CROSSING DETECTORS

The output from each of the 1840 Hz filters driven by the five direction finding receivers is fed to a doppler zero crossing detector card. Diode switching enables the insertion of a calibration waveform into each of these five plug in cards. On each card, an MC1590G AVC controlled amplifier drives half an MC1458 (dual 741), which provides an 8 volt peak to peak signal for rectification by the voltage doubler 2 x IN34A. The resultant 6V DC is applied to the two inputs of an AD512K after passing through RC filters of vastly different time constants. The long time constant (of order 8 seconds) branch also feeds the other half of the MC1458, and provides the groundwave DC level for AGC control. The AGC circuit is diode buffered to provide control of the "no signal" gain of the receiver. The short time constant voltage level is displayed by individual meters on the front panel. This short time constant circuit (of order 5 msec) applies the skywave/groundwave beat signal to the AD512K difference amplifier, and the amplified doppler beat drives the input of one half of an 8T363 zero crossing detector. The output of the zero crossing detector drives both a 74121 schmidt trigger, which produces a 5 msec output pulse for each positive zero crossing, and also one section of a 7404, which effectively inverts the signal, and drives a second 74121 schmidt trigger, which produces a 5 msec output pulse for each negative zero crossing of the doppler signal.

The 1120 Hz output from receiver 2 is separately processed in like manner. The subsequent processing of these output pulses is detailed in the section on the Digital Logic.



DOPPLER ZERO CROSSING DETECTOR (8 of)



CALIBRATOR/CLOCK OSCILLATOR/AUDIO AMPLIFIER

ZERO CROSSING DETECTOR CALIBRATOR

This card provides the voltage to switch the zero crossing detectors from "signal" to "calibrate", as well as generating the calibration waveforms. An NE555 timer produces 10 second output pulses at approximately 1000 second intervals. The second pulse switches the 741 output from negative (signal waveform handled by zero crossing detector) to positive for 10 seconds. The 10 second pulse also opens the gate (¼ 7400) from an 0.5 Hz square wave generator (½ 7400) to the negative trigger input on the digital logic (SOD+). Since this line will then change state 5 times in 10 seconds, five "calibration echoes" will be recorded approximately every 15 minutes. The "calibration echo" signals are produced by two more square wave generators (2/3 7404), one running at 2 k Hz, the other at 5 Hz. The 2 k Hz signal is gated to the outputs via two channels, one of which is switched by an inverted (1/6 7404) 5 Hz square wave. Thus the signals fed to the 2560 Hz* channels of receivers 3, 4, and 5, and the 1840 Hz* channel of receiver 2, all represent 5 Hz "dopplers" in phase, while the 2560 Hz* channel fed to receiver 2 will be 180^{o} out of phase at the doppler frequency of 5 Hz. This will produce a calibration record with all direction finding channels in phase. (The data tape unpacking program DECØDE will recognize the calibration record because its doppler period will be tagged negative, since the calibration "echo" triggers the logic SOD+).

A separate panel mounted switch may also be used to manually record calibration "echoes". This single pole double throw momentary contact switch sets and resets a 7474, which switches the NE555 output gate (¼ 7400) and loads calibration records at the rate of one every 2 seconds for as long as the switch is depressed.

Also mounted on the calibrator card are the CLOCK OSCILLATOR and an A. F. AMPLIFIER. The Clock Oscillator is an International Crystals OE - 10 7.200000 MHz .0001% modular crystal oscillator, with supply voltage regulated by a 1N4739 9v zener diode, and output buffered by a 2N4126, which provides the drive to the clock divider chain on the digital logic chassis.

The A. F. Amplifier is simply an LM380, which amplifies the 1840 Hz output of receiver 2 to provide an audible monitoring signal from the panel mounted speaker.

*For 2560 Hz read 1840 Hz,
for 1840 Hz read 1120 Hz.

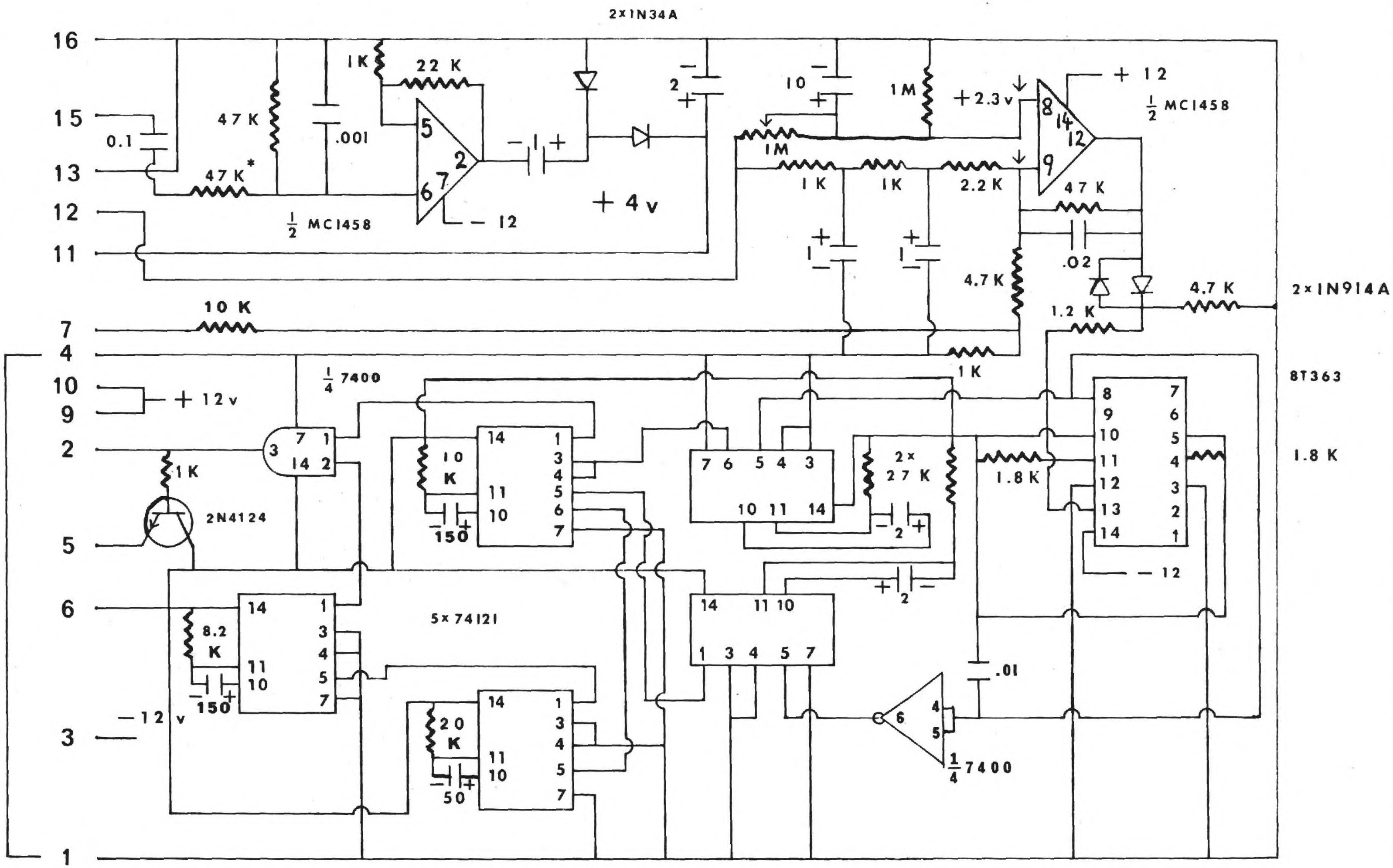
THE ECHO SENSING UNIT

This card continually monitors the 1840 Hz output level of receiver 2. With groundwave only signal present, this level remains constant. However, the presence of skywave produced by a moving target will be accompanied by a level shift at a rate corresponding to the doppler shift. The purpose of the echo sensing unit (ESU) is to provide an indication to the digital logic unit of the presence of an echo.

The input signal is buffered by half of an MC1458, which drives a 2xIN34A voltage doubler, producing a 4V DC level on groundwave alone. A front panel gain controlled carrier balanced amplifier (other half of MC1458) similar to that employed in the doppler zero crossing detectors next drives one half of an 8T363 zero crossing detector. In order to desensitize the 8T363 input (nominal sensitivity $\pm$ 30 mv), drive is applied via a pair of back to back 1N914A's. This provides the circuit with a minimum threshold level of $\pm$ 600 mv, and provides adequate discrimination against triggering on noise.

As in the doppler zero crossing detectors, the 8T363 and 7400 drive individual 74121's. However, in this instance, these shmidt triggers provide a 40 msec delay before triggering a further three 74121's which produce a hold out on continuous dopplers. The 40 msec delay before triggering the digital logic is incorporated to ensure that meteor echoes are not sampled early in their lifetime, when phase changes result from the Fresnel pattern of trail formation, rather than the bodily drift of the trail under the influence of the ambient wind.

The hold out facility ensures that continuous output from the ESU re-



ECHO SENSING UNIT

sults in the presence of a continuing signal. This not only eliminates repeated triggering on aircraft echoes, but also prevents repeated triggering on long duration meteor echoes, which are subject to fading, thereby producing apparently non-coherent dopplers. The time constants of the three final 74121's in the ESU are chosen so that dopplers with periods less than 0.75 sec produce a continuous logic 1 (+ 5v) out of the ¼ 7004 NAND gate which drives the echo sensing input of the digital logic chassis, for as long as the echo lasts. Neither short nor long duration dopplers with periods greater than 0.75 seconds will be recorded on tape, since the phase gating registers will not have finished counting in this interval - one of the criteria necessary for echo validation.

An emitter follower, 2N3643, is also driven by the output line, and lights a panel mounted lamp when the ESU output is high, indicating the presence of an echo.

THE DIGITAL LOGIC CHASSIS

INTRODUCTION

The heart of the Georgia Tech radio meteor wind measuring system is the digital logic chassis. Here, the positive and negative pulses output by the various zero crossing detectors are gated to provide measures, expressed in 15 KHz clock "counts", of the doppler phase relationship between the various receiver filtered outputs. The second section of this chapter defines the receiver outputs in terms of the channels which are sampled. The section on Digital Logic Specifications details the order of sampling, and the loading of the 8 data registers which, if the validation criteria are satisfied, are subsequently transferred character by character to the Kennedy 1610 incrimental tape recorder, and written on tape. All processing to determine echo arrival angle, height, and line of sight wind speed are subsequently performed on campus (see Program DECØDE in The Georgia Tech Radio Meteor Wind Facility Computer Program Library (volume 3 of this series)).

CHANNEL DEFINITION

Initiating pulse, plus doppler period	Channel 1	Output of 1840 H_Z channel of rcvr 2
Phase 1	Channel 2	" rcvr 1
Phase 2	Channel 3	" rcvr 3
Phase 3	Channel 4	" rcvr 4
Phase 4	Channel 5	" rcvr 5
Range	Channel 6	Output of 1120H_Z channel of rcvr 2
Range check	Channel 1 ON and Channel 6 OFF	Opposite polarity pulses to initiating pulse
Doppler check	Channel 1	Opposite polarity pulses to initiating pulse

(Doppler frequency lies between 2 and 25 H_Z)

DIGITAL LOGIC SPECIFICATIONS

Valid Echo - appearance of signal (logic 1) out of echo sensing unit (ESU); logic 1 = +5v, logic 0 = 0v.

First positive (or exclusive negative) 5 ms pulse out of channel 1 starts 6 of 16 bit registers counting pulses from 15 KHz clock

Next positive (or exclusive negative) pulse out of channel 1 stops register 1 counting.

Next positive (or exclusive negative) pulse out of channel 2 after initial channel 1 trigger stops register 2 counting

	channel 3
register 3	channel 4
register 4	channel 5
register 5	channel 6
register 6	

i. e. if first pulse out of channel 1 is +ve, all subsequent gating is by positive pulses

OR if first pulse out of channel 1 is - ve, all subsequent gating is by negative pulses

In addition, a 7th register clocks the interval between the first negative pulse out of channel 1 and the first subsequent negative pulse out of channel 6, if the initial channel 1 pulse is positive, or the corresponding two positive pulses out of channels 1 and 6, if the initial channel 1 pulse is negative.

Similarly, an 8th register clocks the interval between the first two negative pulses of channel 1, if the initial channel 1 pulse is positive, OR, if the initial channel 1 pulse is negative, the 8th register clocks the interval between the first two positive pulses of channel 1.

All registers HOLD after gating off (regardless of further outputs from channels 1 through 6).

At 0.75 secs after the initial (+ve OR -ve) pulse out of channel 1, check all 8 registers are on HOLD - if not, check until there is no signal out of the echo sensing unit (validation) channel, reset all registers to zero, and await next echo. Do not restart until ESU output is logic 0.

If all 8 registers are on HOLD, load successive registers serially into Kennedy 1610 tape deck, plus clock TIME (displayed numerically on front panel of unit) as in Table 1.

i.e. a total of	11 of 16 bit registers
plus	1 of 4 bit register
or	12 of 16 bit registers (with 8 bits of 12th register not used).

Data is in fact loaded into 32 of 4 bit registers, with 52 bits of TIME being strobed out of the clock during the writing of each record.

This yields a total of 180 bits, or 5 of 36 bit words (which are written in U1108 compatible format by the Kennedy 1610).

Upon completion of tape write (including inter-record gap after 5 words are written) test the output of the echo sensing unit - if logic 0, reset all registers to zero and await next echo. If not, wait for ESU logic 0, and then reset.

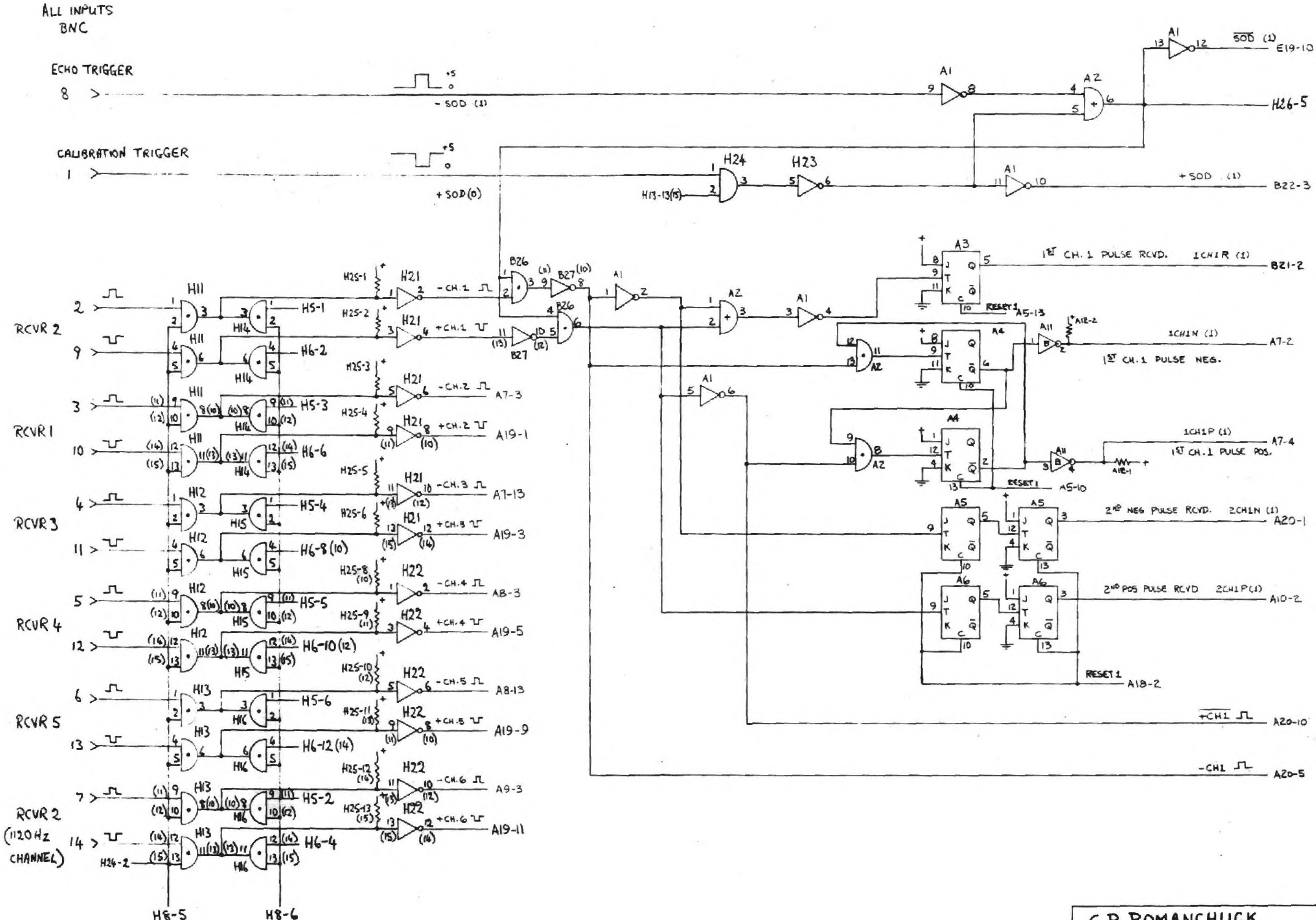
TABLE I.

	4 bit	BCD	Year	thousands	register	
16 BITS	"	"	"	hundreds	"	
	"	"	"	tens	"	constant data (Manually set)
	"	"	"	units	"	
16 BITS	"	"	Year day	hundreds	"	
	"	"	"	tens	"	
	"	"	"	units	"	
	"	"	Hours	tens	"	controlled by manually re-settable clock
16 BITS	"	"	"	units	"	
	"	"	Minutes	tens	"	
	"	"	"	units	"	
	"	"	Seconds	tens	"	
4 BITS	"	"	"	units	"	

THE LOGIC CALIBRATOR

The Logic Calibrator is plane H of the digital logic chassis. It provides front panel display of the contents of the logic counting registers via panel switching (S14, S15) which steps through the data enable gates 6 at a time, displaying the character count (0 to 29) on a two digit decade display, and the 6 bit character via panel mounted LEDS. Another LED flashes a warning signal when the logic is in the stepping mode. A square wave generator and divide chain (H1 - H9) provides a series of output pulses which can be gated into the six channels of the signal pulse stream by actuating a panel mounted switch (S16). Another LED flashes when S16 is in the "calibrate" position. Actuating S16 also gates a trigger pulse through H24 and H23 to the SOD$\downarrow$ stream, ensuring that the "doppler" will be tagged with a negative sign, and therefore will be recognized as a calibration record by the data tape unpacking program DECØDE.

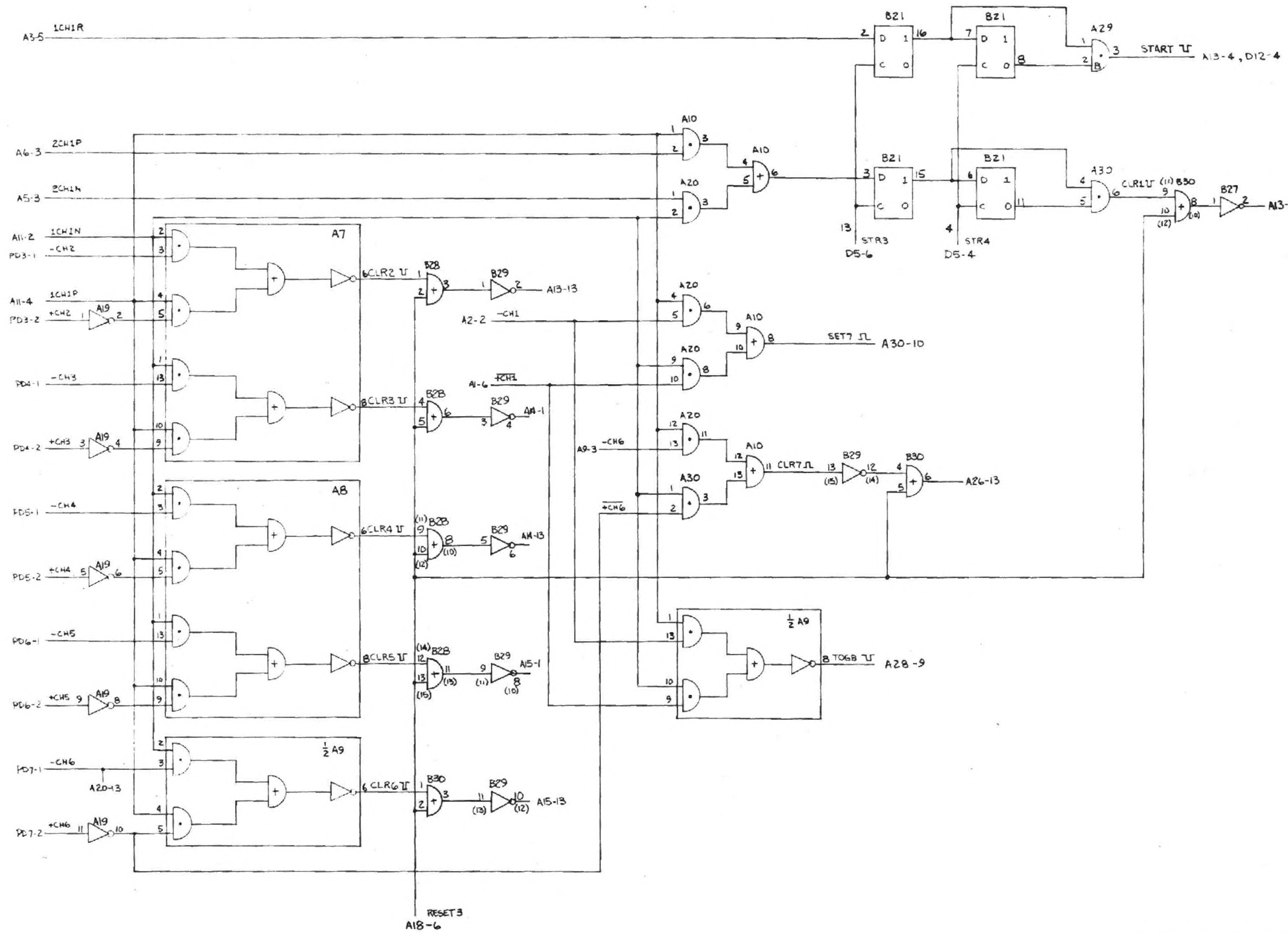
Three hex inverters in H20 are used to monitor the system state. If no echo is being recorded, a green LED is alight. If an echo (or calibration record) is being recorded, a red LED lights. The "Gap in Progress" signal from the tape recorder lights an orage LED.



C.R. ROMANCHUCK
R.G. ROPER

CHAN. 1 SEQUENCING

1 MAY 75 | 1 of 8



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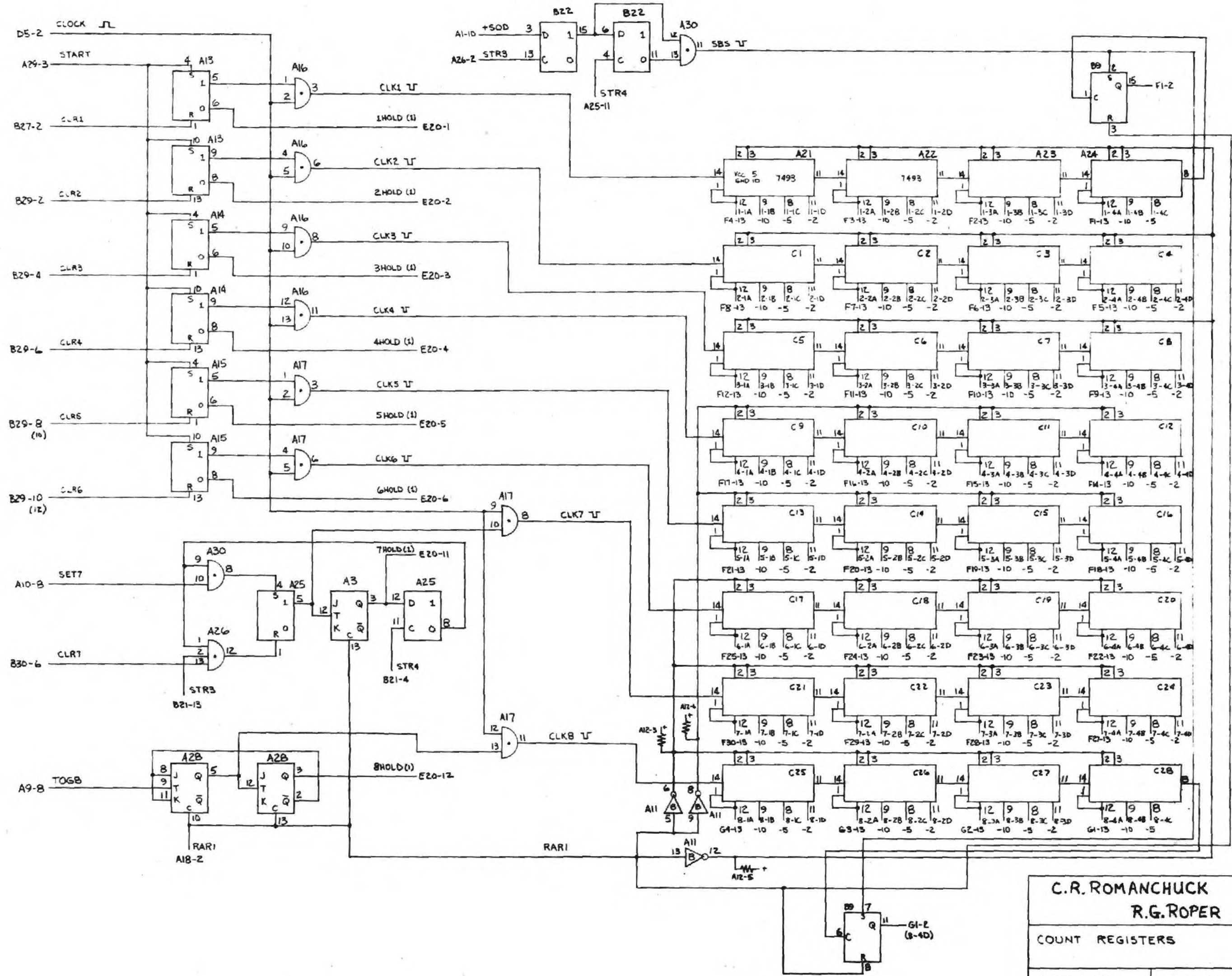
R.G. ROPER

REGISTER CONTROL PULSE CIRCUITS

9 FEB 74 | 2 OF 8



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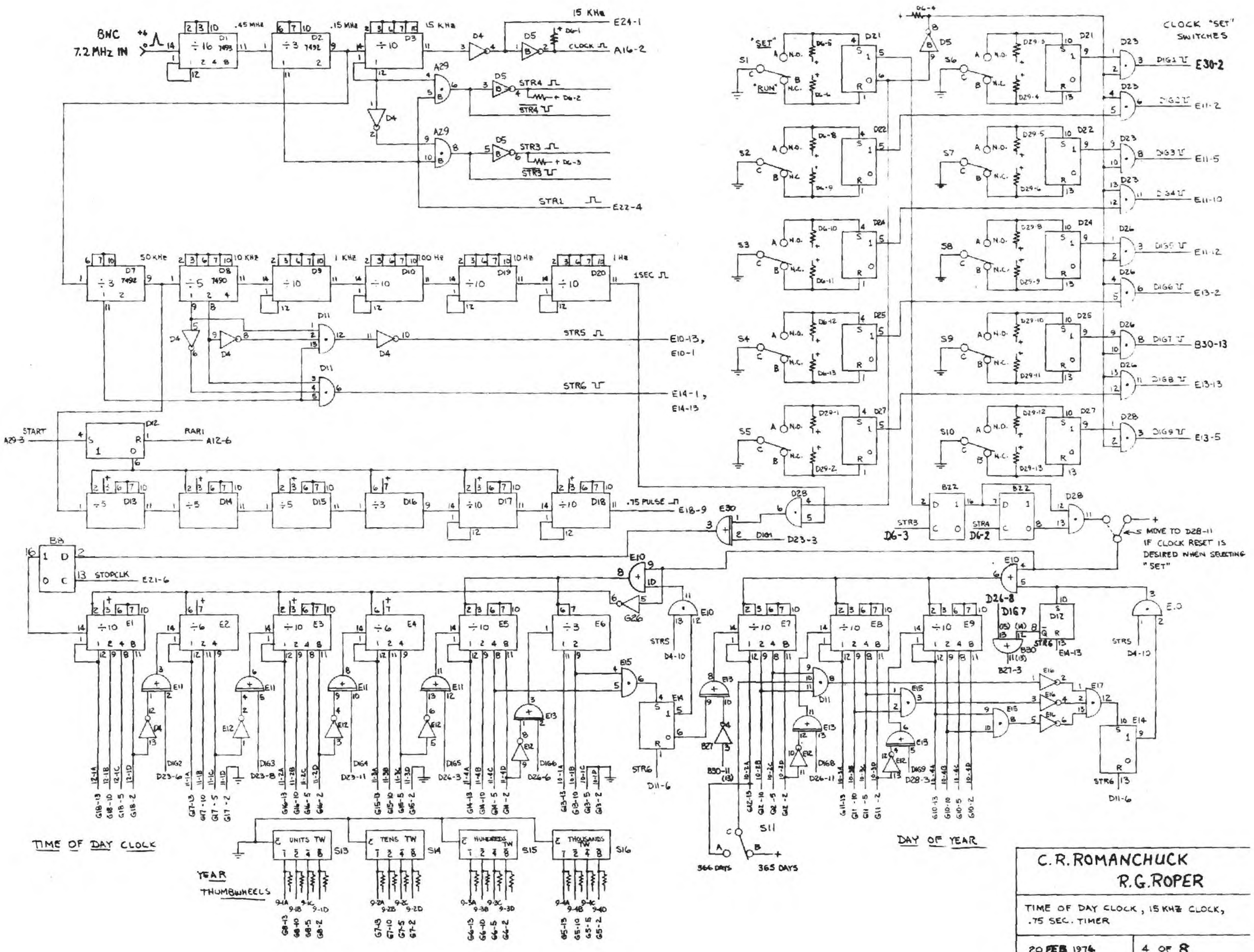
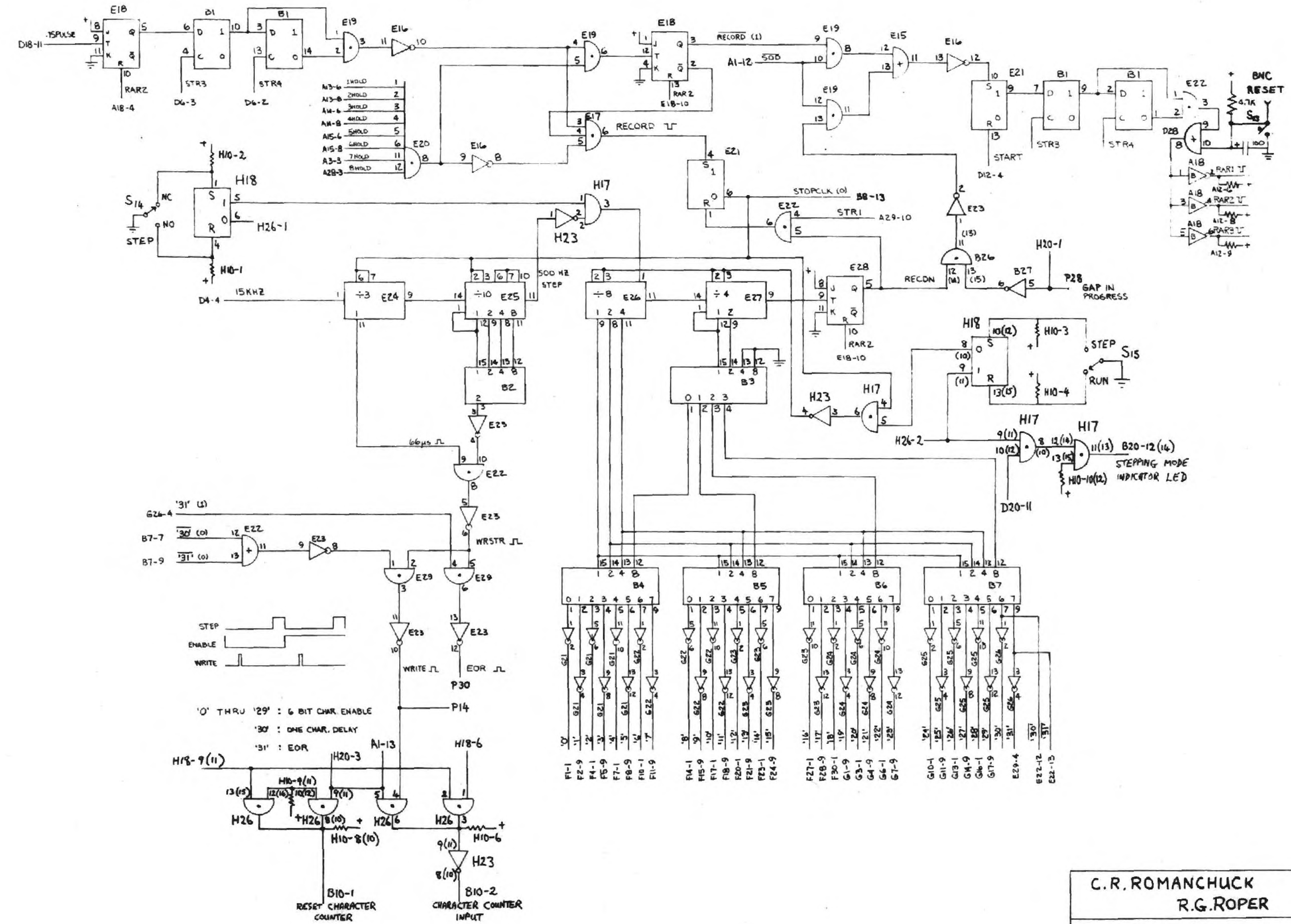
R.G. ROPER

COUNT REGISTERS

10 FEB 74 | 3 of 8


BNC
7.2 MHz IN
CLOCK "SET" SWITCHES
"SET"
"RUN"
15 KHz
1SEC
.75 PULSE
START
STOPCLK
MOVE TO D28-11 IF CLOCK RESET IS DESIRED WHEN SELECTING "SET"
TIME OF DAY CLOCK
DAY OF YEAR
YEAR THUMBWHEELS
UNITS TW
TENS TW
HUNDREDS TW
THOUSANDS TW
366 DAYS
365 DAYS
C. R. ROMANCHUCK
R. G. ROPER
TIME OF DAY CLOCK, 15 KHZ CLOCK, .75 SEC. TIMER
20 FEB 1974
4 OF 8



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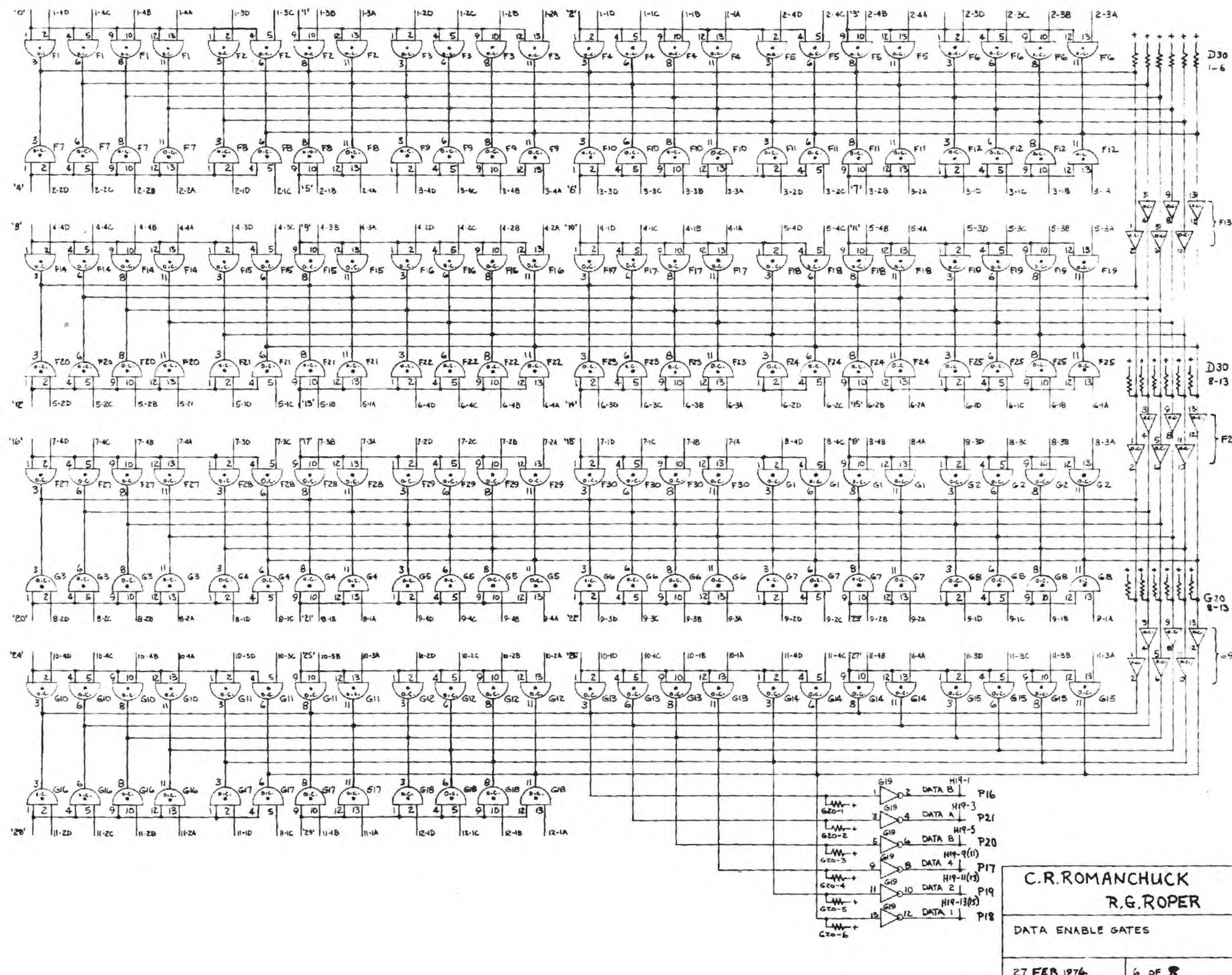
R.G. ROPER

TAPE RECORDER CONTROL, REGISTER ADDRESSING, & REGISTER RESETS

1 MAY 1975	5 of 8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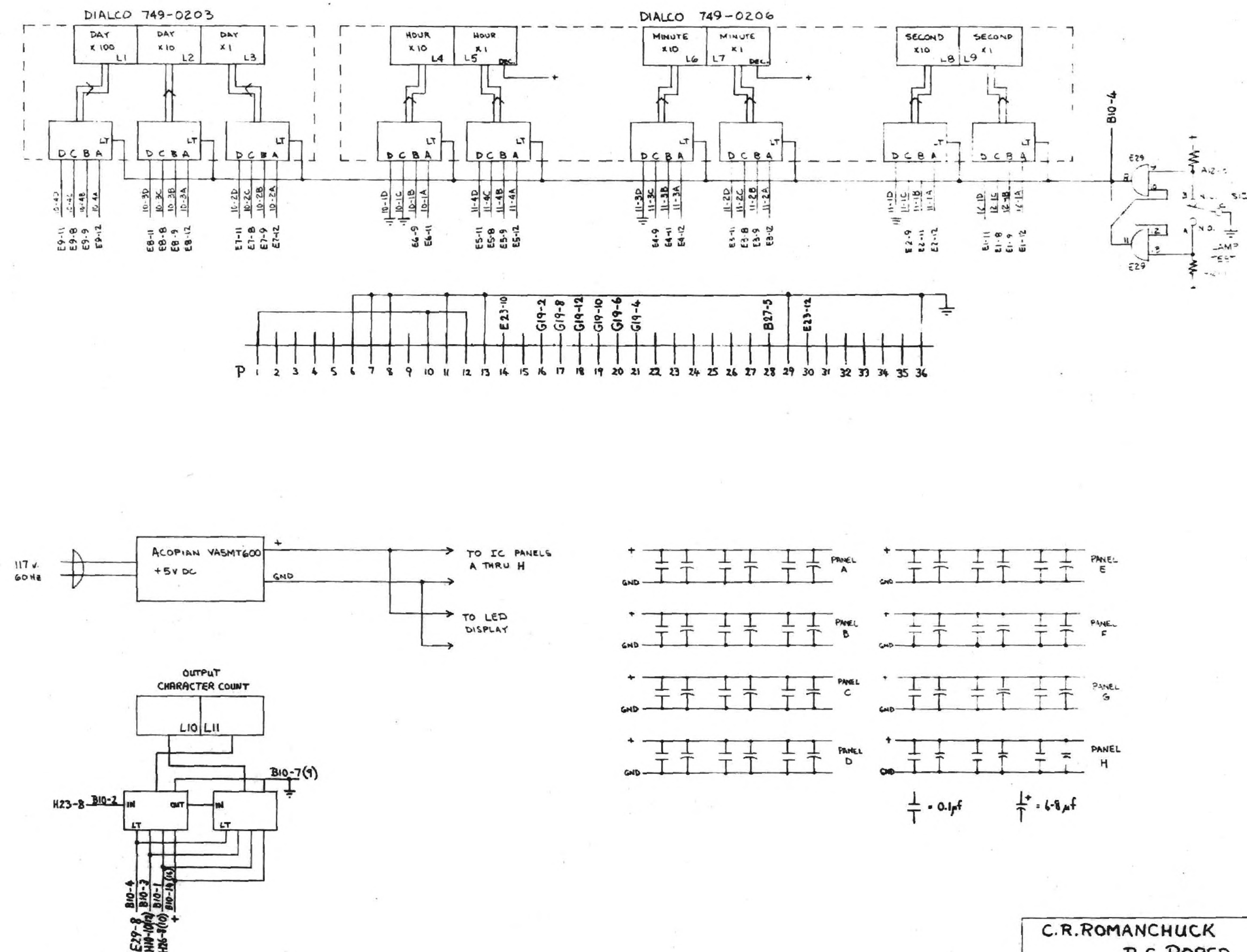
R.G.ROPER
DATA ENABLE GATES
27 FEB 1974
6 OF 8



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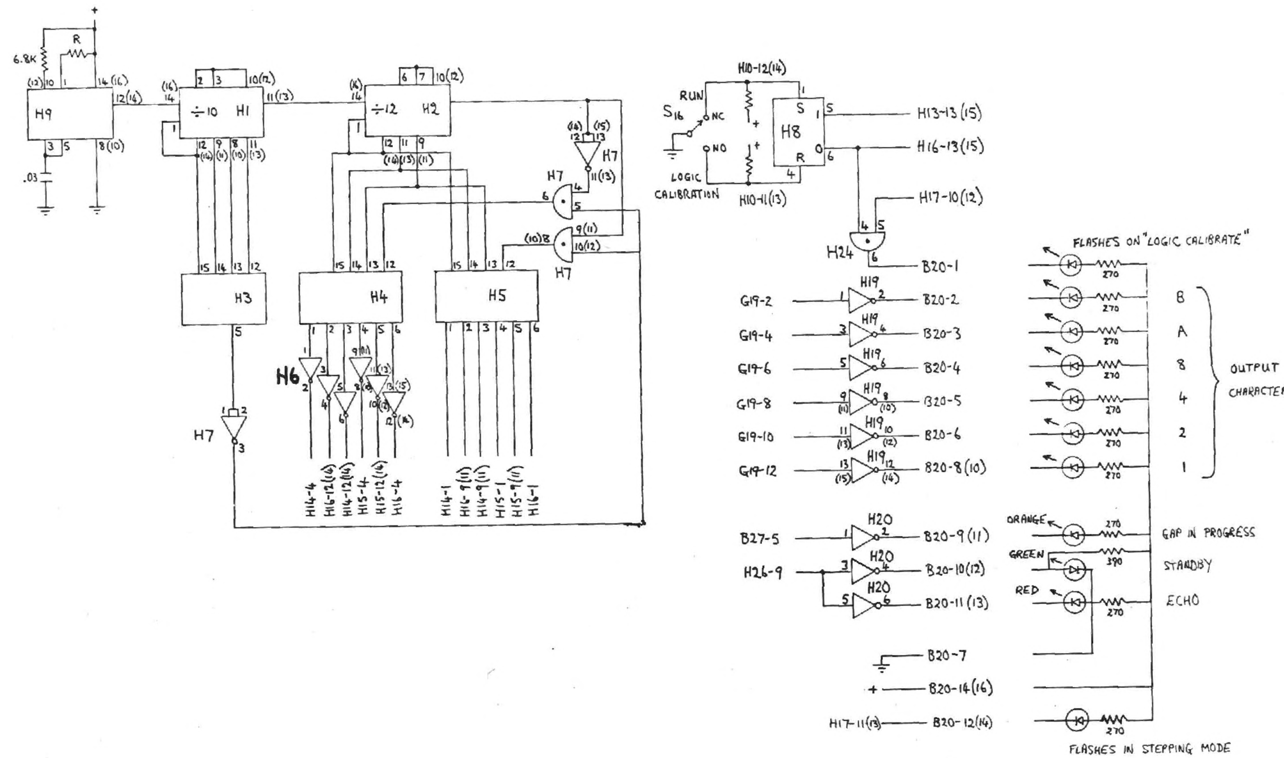
DIGITAL DISPLAYS & DC POWER
TAPE RECORDER WRITE INTERFACE

27 FEB 1974 | 7 of 8



C.R. ROMANCHUCK
R.G. ROPER

TEST RECORD GENERATOR
OUTPUT CHARACTER DISPLAY
SYSTEM STATE MONITOR

13 MAY 1975 | 8 OF 8

DIGITAL LOGIC DIP INVENTORY

GROUP A

1.	7404	11.	7406	21.	7493
2.	7400	12.	914C	22.	7493
3.	74107	13.	7474	23.	7493
4.	74107	14.	7474	24.	7493
5.	74107	15.	7474	25.	7474
6.	74107	16.	7400	26.	7410
7.	7451	17.	7400	27.	
8.	7451	18.	7406	28.	74107
9.	7451	19.	7404	29.	7437
10.	7400	20.	7400	30	7400

GROUP B

1.	7475	11.		21.	7475
2.	7442	12.		22.	7475
3.	7442	13.		23.	
4.	7442	14.		24.	
5.	7442	15.		25.	
6.	7442	16.		26.	7400
7.	7442	17.		27.	7404
8.	7475	18.		28.	7400
9.	7476	19.		29.	7404
10.		20.		30.	7400

DIGITAL LOGIC DIP INVENTORY (CONTD)

GROUP C

1.	7493	11.	7493	21.	7493
2.	7493	12.	7493	22.	7493
3.	7493	13.	7493	23.	7493
4.	7493	14.	7493	24.	7493
5.	7493	15.	7493	25.	7493
6.	7493	16.	7493	26.	7493
7.	7493	17.	7493	27.	7493
8.	7493	18.	7493	28.	7493
9.	7493	19.	7493	29.	
10.	7493	20.	7493	30.	

GROUP D

1.	7493	11.	7410	21.	7474
2.	7492	12.	7474	22.	7474
3.	7490	13.	7490	23.	7400
4.	7404	14.	7490	24.	7474
5.	7406	15.	7490	25.	7474
6.	914C	16.	7492	26.	7400
7.	7492	17.	7490	27.	7474
8.	7490	18.	7490	28.	7400
9.	7490	19.	7490	29.	914C
10.	7490	20.	7490	30.	914C

DIGITAL LOGIC DIP INVENTORY (CONTD)

GROUP E

1.	7490	11.	7486	21.	7474
2.	7492	12.	7404	22.	7400
3.	7490	13.	7486	23.	7404
4.	7492	14.	7474	24.	7492
5.	7490	15.	7400	25.	7490
6.	7492	16.	7404	26.	7493
7.	7490	17.	7410	27.	7493
8.	7490	18.	74107	28.	74107
9.	7490	19.	7400	29.	7400
10.	7400	20.	7430	30.	7486

GROUP F

1.	7403	11.	7403	21.	7403
2.	7403	12.	7403	22.	7403
3.	7403	13.	7407	23.	7403
4.	7403	14.	7403	24.	7403
5.	7403	15.	7403	25.	7403
6.	7403	16.	7403	26.	7407
7.	7403	17.	7403	27.	7403
8.	7403	18.	7403	28.	7403
9.	7403	19.	7403	29.	7403
10.	7403	20.	7403	30.	7403

DIGITAL LOGIC DIP INVENTORY (CONTD)

GROUP G

1.	7403	11.	7403	21.	7404
2.	7403	12.	7403	22.	7404
3.	7403	13.	7403	23.	7404
4.	7403	14.	7403	24.	7404
5.	7403	15.	7403	25.	7404
6.	7403	16.	7403	26.	7404
7.	7403	17.	7403	27.	
8.	7403	18.	7403	28.	
9.	7407	19.	7404	29.	
10.	7403	20.	914C	30.	

GROUP H

1.	7490	11.	7403	21.	7404
2.	7492	12.	7403	22.	7404
3.	7442	13.	7403	23.	7404
4.	7442	14.	7403	24.	7400
5.	7442	15.	7403	25.	914C
6.	7404	16.	7403	26.	7403
7.	7400	17.	7400	27.	
8.	7474	18.	7474	28.	
9.	XR320	19.	7405	29.	
10.	914C	20.	7405	30.	

THE KENNEDY MODEL 1610 INCREMENTAL TAPE RECORDER

The Kennedy 1610 magnetic tape recorder is controlled by the digital logic chassis, which provides write enable, write step, and data characters.

The manufacturer offers several options on this unit. A seven track format, compatible with the UNIVAC 1108, written at a speed of 500 characters per second, with a density of 556 characters to the inch, was selected. Further details on additional options available from the manufacturers, Kennedy Co., 540, West Woodbury Road, Altadena, California 91001.

CHAR	B	A	8	4	2	1
0	REG.1 MSB	→	→	→	→	→
1	→	→	→	→	→	→
2	→	→	→	→	REG.2 MSB	→
3	→	→	→	→	→	→
4	→	→	→	→	→	→
5	→	→	REG.3 MSB	→	→	→
6	→	→	→	→	→	→
7	→	→	→	→	→	→
8	REG.4 MSB	→	→	→	→	→
9	→	→	→	→	→	→
10	→	→	→	→	REG.5 MSB	→
11	→	→	→	→	→	→
12	→	→	→	→	→	→
13	→	→	REG.6 MSB	→	→	→
14	→	→	→	→	→	→
15	→	→	→	→	→	→
16	REG.7 MSB	→	→	→	→	→
17	→	→	→	→	→	→
18	→	→	→	→	REG.8 MSB	→
19	→	→	→	→	→	→
20	→	→	→	→	→	→
21	→	→	YEAR 8000	4000	2000	1000
22	800	400	200	100	80	40
23	20	10	8	4	2	1
24	DAY 800	400	200	100	80	40
25	20	10	8	4	2	1
26	HOUR 80	40	20	10	8	4
27	2	1	Min. 80	40	20	10
28	8	4	2	1	Sec. 80	40
29	20	10	8	4	2	1

CHARACTERS WRITTEN BY KENNEDY 1610 7 TRACK RECORDER

POWER SUPPLIES

Two commercial power supply units are used:

1. A Sorensen Mod I 12-1D provides $\pm$ 12v @ 1A*.

2. An Acopian Series A VA5MT600 provides +5v @ 6A*.

AC power is supplied both these units through an RF line filter and panel mounted 1 amp fuse and ON/OFF switch.

* Main requirements are high regulation and low ripple. Both supplies have proved more than adequate.

REFERENCES

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Orr, William I., Radio Handbook, 19, Editors and Engineers, Indianappolis, p. 4.6, 1972.

Roper, Robert G., "The Adelaide Meteor Wind Equipment", NASA Tech. Publcn., X-651-65-102, Goddard Space Flight Center, Greenbelt, Md., 1965.

Weiss, A. A. and W. G. Elford, "An Equipment for Combined Geophysical and Astronimical Measurements of Meteors", Proc. I. R. E., Australia, 24, 197, 1963.

RECEIVER COIL DATA

L_1, L_3	4T No. 26 AWG	on T-50-6 Amidon Toroids
L_2, L_4	12T No. 26 AWG	
L_5, L_7, L_9	20T No. 26 AWG	on T-50-2 Amidon toroids
L_6, L_8, L_{10}	6T No. 26 AWG	

1ST LOCAL OSCILLATOR

L_1	15T No. 26 AWG	on T-50-6 Amidon toroid
L_2	5T No. 26 AWG	
RFC	6T No. 26 AWG	on T-50-6 Amidon toroid

AFC DISCRIMINATOR

T_1, T_2	22 mh/22 mh toroidal inductors

THE GEORGIA TECH RADIO METEOR WIND FACILITY
COMPUTER PROGRAM LIBRARY

Contents

THE GEORGIA TECH RADIO METEOR WIND SYSTEM
DATA SIMULATION, REDUCTION AND ANALYSIS PROGRAMS

Section I. The Site Coordinate Transformation Program LØCATE

Before one can proceed with the simulation or reduction of radio meteor echoes, the parameters of the transmit/receive system must be detailed. The CW method of operation requires separation of the transmitter and receivers such that the groundwave has an amplitude comparable to the skywave reflected from an "average" meteor trail. For the GT System effective radiated power of 1.0 KW (one sideband of the double sideband suppressed carrier on 32.5 MHz), this amplitude is ~ 10 microvolts. In the rolling hill topography around Atlanta, a location 27 kilometers NE of the campus, which had been suggested as a possible field site by the management of Technology Park/Atlanta (TPA is a newly established research park near Norcross, Georgia) proved to be suitable.

The computer program LØCATE was written to determine the site constants, and is reproduced here for the benefit of those contemplating a similar meteor radar facility.

The U1108 Fortran V Program LØCATE.

This program contains, as internal data, the latitude, longitude and height above mean sea level of both transmitting and receiving sites, and generates the mean earth radius, T/R system midpoint coordinates, and the rotation factors to be applied to the measurements made at the receiving site to express all arrival angles and ranges in terms of the origin appropriate to the measured line of site drift vectors, and a north/south - east/west - vertical coordinate system. This is done by calls to

SUBRØUTINE CØØRD

which establishes the geocentric coordinates of the sites, and to

SUBRØUTINE TØPØ

which performs the topocentric computations.

Also included for completeness are tabulations of the corrections to be applied to the arrival angle direction cosines as measured at the receiving site (such corrections having been determined by an antenna calibration), and the correction for conversion of local (clock) time to local mean solar time. Whereas the GT System records the Eastern Standard Time of each echo received, more meaningful comparisons, particularly of tidal wind phases, can be made if all data is measured in local mean solar time.

The output of the program consists of a listing of the input site latitudes and longitudes, in degrees, minutes and seconds, the site separation, in kilometers, the midpoint coordinates relative to the receiving site in kilometers, the antenna calibration correction factors, the sin and cosine of the T/R system to NS - EW rotation, and the "clock" to local mean solar time correction factors. These parameters, with the exception of the lat/lons., are used as constant data within both the echo data simulation program METEØR, and the echo data tape reading program DECØDE.

While not applicable to the GT System, occassions may arise when there is enough difference between the heights above sea level of the transmitting and receiving sites that a correction needs to be made to convert site system vertical to true vertical. This is the angle EL output by SUBRØUTINE TØPØ, which is the depression angle in radians of the receiving site with respect to the transmitting site. If EL is significant (of order 1° or more), AZ and EL can be used to perform a three dimensional rotation from site coordinates axes to NS, EW, vertical. The three dimensional rotation algorithm is <u>not</u> included in the Georgia Tech programs SITE, METEØR, and DECØDE.

Section II. The Receiving Station Simulation Program METEØR

Introduction

The Georgia Tech Radio Meteor Wind Project is designed after the project which has been pursued so successfully since 1950 by the Physics Department of the University of Adelaide, South Australia, under the leadership of Dr. W. G. Elford. Two important changes have been made:

(1) The Tech ranging system uses phase comparison of the sidebands of a double sideband suppressed carrier signal to determine the echo range, and

(2) The output of the receivers is digitized and written on magnetic tape, instead of being recorded in analog form on film which has subsequently to be processed and read. Certain of the film reading processes are performed during digitization, and the tape written contains relative phase, rather than analog, information, as well as the date and time of day (to the nearest second), which identifies each echo as a separate entity.

In the initial design of the digitizer, an empirical estimate of the sampling frequency was made, based on the known behavior of the target (the first Fresnel zone about the specular reflection point on the ionized trail of the meteor). Horizontal wind speed maxima are normally less than 200 meters sec^{-1}. At an (average) elevation angle of 45^o, this results in a line of sight trail drift velocity, if measured in the maximum flow speed direction, of $200 \sin 45^o = 140$ meters sec^{-1}; such a drift velocity will result, at a radio frequency wavelength of 10 meters, in a doppler shift of just under 30 Hz. If we wish to know the phase of such a wave to better than 1^o (the order of accuracy achieved in the Adelaide system) then it is reasonable to take 500 samples per cycle of the 30 Hz signal. Thus a sampling rate of 15 KHz empirically satisfied our design criteria.

In order to evaluate the performance of the system, the meteor data simulation program METEØR was written.

The U1108 Fortran V Program METEØR

The program generates, from internal data, a set of echoes at random azimuths and elevation angles, in non uniform time steps, with line of sight drifts appropriate to a known wind field; (the wind field chosen has a cubic variation in wind speed with height in both the north-south and east-west directions; a constant vertical wind speed with height, and prevailing, diurnal, semidiurnal and terdiurnal variations in all three wind components with time. The field is not unlike that actually measured at Adelaide in September, 1961). This echo set is then formatted and, depending on the options selected on the first data card (see Appendix I), writes a FASTRAND file for input to the data analysis programs GRØVES and ERG (see Sections 5 and 6); punches cards which can be input to GRØVES or ERG by a LØADIT series program (Section 4); lists the card images; codes the direction cosine and velocity information into digital "phases" and loads these onto FASTRAND as 5 of 36 bit words packed with 16 bit "phase" words and 4 bit "time code" words, a direct simulation of the output tape written by the Kennedy Model 1610 tape recorder at the receiving site (as input for the unpacking and decoding program DECØDE); and/or lists the octal content of these 5 words. Options are also available to add "noise" to the doppler velocity, and/or the relative phase counts, to enable an estimate to be made of the effects of errors in the input data on the subsequent reduction and analysis programs.

The Program

Program elements are detailed in the sequence in which they are called during a run. The elements linking the subroutines constitute the MAIN PRØGRAM.

After initialization, a header card detailing the nature and source of the data is read and written as the lead record on the file FILE2, set aside for data which can be input to GRØVES or ERG. Next, the three data cards determining the output options and output file names which are all listed at the head of the output listing are read, followed by a call to

SUBROUTINE ADATA.

This "data" subroutine sets the start time in minutes from which the time of each echo is calculated, the height limits over which the wind profile model was initially determined, and the coefficients of the model wind variation with height and time.

MAIN then calculates the echo azimuth by a call to

SUBROUTINE UNØISE.

UNØISE is an entry point in the subroutine NØISE and results in the calculation of one of a uniformly distributed set of azimuths lying in the interval 0 to 360°. If an azimuth is calculated which lies outside these limits, another one of the set is calculated until the constraint is satisfied.

MAIN then determines the echo elevation angle by a call to

SUBROUTINE NØISE

NØISE calculates one of a normally distributed set of elevation angles lying in the interval 30° to 80°. If an elevation angle is calculated which lies outside these limits, another one of the set is calculated until the constraint is satisfied.

MAIN then converts these azimuth and elevation angles to direction cosines, which are used in all subsequent analysis programs to specify the line of sight drift directions.

MAIN then determines the height of the reflection center of the echo by another call to NØISE, which calculates one of a set of normally distributed numbers in the interval 70 to 110 kilometers (or 77 to 104 kilometers, depending on the height range option requested). If the height calculated lies outside the selected limits, another height is calculated until the constraint is satisfied.

The true height thus calculated is then reduced to an apparent "flat earth" height by subtraction of that part of the height due to the curvature of the earth. A first order solution, of the form

$$zz = z - \frac{x^2 + y^2}{2R}$$

is used, where x and y are the coordinates of the point vertically below the echo, with the transmit/receive system midpoint taken as origin, and R is the earth's radius. All distances are in kilometers.

The echo range is then calculated using "flat earth" geometry and the echo height zz. This is followed by rotation and translation of axes (see Appendices IIB and IIC), and site correction, to produce direction cosines as would actually apply to the given echo as received at the receiving site. The time of occurrence of the echo is then calculated by another call to NØISE, which results in the occurrence intervals averaging 2.5 minutes,with an RMS deviation of 1.0 minutes (this results in approximately 400 "useable" echoes a day, a typical average rate for a meteor wind facility). Time is then converted to days, hours, minutes and seconds. The line of sight drift appropriate to the height, time, and direction of doppler measurement are then calculated by a call to

SUBROUTINE WIND.

WIND is a modification of subroutine DIANA (see program GRØVES, section V) which calculates, from the coefficients of ADATA and the time and height parameters of the echo, the three appropriate wind components. MAIN then combines these with the determined line of sight direction cosines, to give the appropriate line of sight velocity. If the relevant option has been specified, this velocity can be rendered noisy (corresponding to a random error in actual velocity determination) by a call to

SUBROUTINE VNØISE.

VNØISE is just another compilation of NØISE which handles integers and produces a normally distributed set of velocities with a given rms deviation (as read in on the options data card). A separate routine is used, so that integers can be handled, and adding noise to the drift velocity does not change the distributions of echo arrival angle, height, and time of occurrence. Because the recording interval of the digitizer is 0.75 sec echo^{-1}, velocities less than some 10 meters sec^{-1} will not be recorded in the field. If the drift velocity determined is less than this figure, a completely new echo is chosen (just as would be the case for the actual system). An <u>advancing</u> echo (one for which the phase path is decreasing) results in a skywave radio frequency greater than the groundwave frequency, and is coded <u>positive</u>.

Next, the components of the drift (considered as purely horizontal) are calculated. These can be used to calculate a "quick look" type of hour by hour wind.

If the receiving site data option has been specified, the program then proceeds to convert the echo data to the appropriate form. First the number of 15 KHz counts appropriate to the time taken for one doppler cycle is determined, by dividing the drift velocity into 69231, the number of counts corresponding to the period of a beat generated by a line of sight drift velocity of 1 meter sec^{-1} at a radio frequency of 32.5 MHz. Note again that this quantity, called WAVE in the program, has a sign which is positive if the line of sight drift is toward the receiving antennae, and negative if the phase path is increasing. Since both pairs of crossover points of the first one and a half cycles of the doppler at the receiving site are recorded (to check consistency of the doppler) a second measure of WAVE is determined. If the option is desired, the two values will be the same. However, the second value is usually determined by another call to NØISE. This second doppler period is one of a set of normally distributed numbers of average WAVE with a 10% RMS spread.

Since the sense of trail drift is determined from the relative phases at the receiving antennas in the subsequent echo analysis program DECØDE, the absolute values of the number of counts corresponding to WAVE and its "second value" are stored as MWAVE1, MWAVE2.

MAIN then simulates the relative phases between the beats appearing at each receiver output for a given echo arrival angle and velocity by a call to

SUBROUTINE ECHØDF

For an understanding of this subroutine, it is necessary to consider the beats produced between the transmitted groundwave and the reflected skywave at each of the 5 antennae which make up the direction finding array.

A plan view of the array is detailed in Figure 1. Consider a skywave, which results from reflection from a trail advancing toward the antenna system

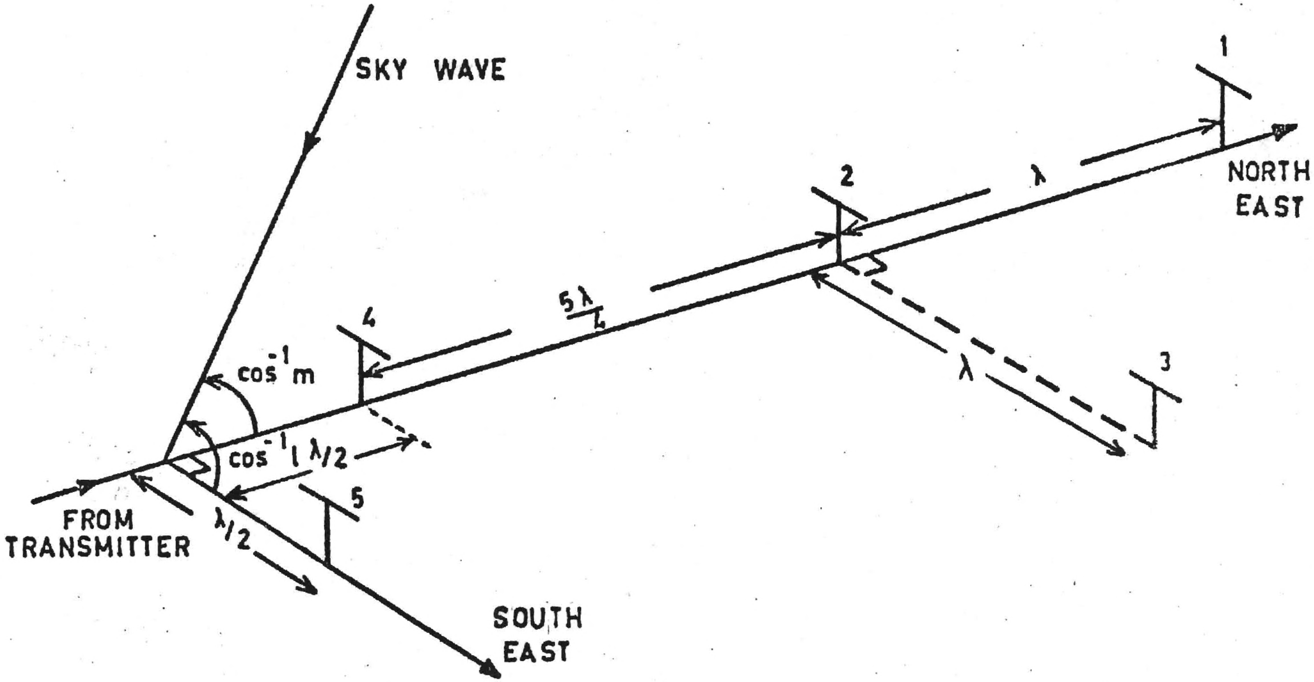


FIGURE 1 - LAYOUT OF DIRECTION FINDING AERIALS

(phase path decreasing, WAVE > 0). The phases as measured at the various antennae are

$$1 \text{ leads } 2 \text{ by } 2\pi.m$$

$$3 \text{ leads } 2 \text{ by } 2\pi.\ell$$

$$2 \text{ leads } 4 \text{ by } 2\pi.5/4.m$$

$$4 \text{ leads } 5 \text{ by } 2\pi.1/2.m - 2\pi.1/2.\ell$$

It is convenient to take the phase as measured at antenna 2 as the reference, and relate all other phases to the phase at 2. Then

$$2 \text{ leads } 5 \text{ by } 2\pi.5/4.m + 2\pi.1/2.m - 2\pi.1/2.\ell$$

$$= 2\pi(1.75m - 0.5\ell)$$

The groundwave "arrives" at each antenna such that

$$1 \text{ leads } 2 \text{ by } - 2\pi$$

$$3 \text{ leads } 2 \text{ by } 0$$

$$2 \text{ leads } 4 \text{ by } - 2\pi.5/4$$

$$2 \text{ leads } 5 \text{ by } - 2\pi\ (5/4 + 1/2)$$

The beats between the skywave and groundwave at each antenna result in beat envelopes having the same relative phases as the original radio frequency signals. The beat waveforms will have relative phases given by:

$$1 \text{ leads } 2 \text{ by } 2\pi\ (m + 1)$$

$$3 \text{ leads } 2 \text{ by } 2\pi\ell$$

$$2 \text{ leads } 4 \text{ by } 2\pi.5/4.(m + 1)$$

$$2 \text{ leads } 5 \text{ by } 2\pi\ (1.75m - 0.5\ell + 1.75)$$

Let us suppose we measure phase differences between the minima of the beat waveforms (whether minima, or maxima, or corresponding crossover points is immaterial, provided consistency is observed). Using 2 as the reference,

$$2 \text{ leads } 1 \text{ by } -2\pi(m + 1)$$

$$2 \text{ leads } 3 \text{ by } -2\pi\ell$$

$$2 \text{ leads } 4 \text{ by } 2\pi \times 1.25 \times (m + 1)$$

and

$$2 \text{ leads } 5 \text{ by } 2\pi(1.75m - 0.5\ell)$$

In terms of the program direction cosines EL and EM, the number of counts per doppler cycle WAVE (= 2π above), and the fact that addition or subtraction of a complete cycle makes no difference to the relative phases, the solution can be presented as

```
2 leads 1 by - WAVE * EM                           = MA
2 leads 3 by - WAVE * EL                           = MB
2 leads 4 by WAVE * 1.25 * (EM + 1.0)              = MC
```

and

```
2 leads 5 by WAVE * (1.75 * EM - 0.5 * EL + 0.75) = MD
```

As calculated, each of these quantities may be negative, or larger than WAVE. Therefore, each is normalized, in turn, by a call to

SUBROUTINE NØRMAL

which adds or subtracts appropriate multiples of |WAVE| until the quantity lies in the interval 0, |WAVE|; i.e. the interval in which the clock counts are actually measured. (Addition or subtraction of 2π makes no difference to the relative phases).

An option is available to add noise to the doppler phases, including the range "phase", the phase difference between the upper and lower sideband dopplers, which is calculated in this section of MAIN. If specified, calls are made to

SUBROUTINE VNØISE

again. Gradual increase in the indeterminancy of the relative phases is another means of checking the sensitivity of the subsequent reduction and analysis programs to random errors in the input data (caused, for example, by a decrease in the signal to noise ratio).

MAIN then calculates a second, slightly different echo range (corresponding to the second determination of range at the receiving site) by another call to

SUBROUTINE NØISE.

This option can be suppressed, if desired, and two equal ranges will be produced.

Next, the echo timing words are constructed, such that hundreds, tens and units of each of the quantities MYRDAY (day of year), LTIMH (local time in hours), LTIMM (local time in minutes), and LTIMS (local time in seconds) are stored as separate BCD words. Although the subsequent analysis programs involve echo times measured to the nearest minute only, the time in seconds, which is actually digitized and recorded at the receiving site, is simulated.

A calculated 0 is often stored as -0, becoming the complement tagged with a negative sign bit; all times are actually positive, and so all quantities are IABS'd to prevent the occurrence of complemented words.

Next the U1108 FLD function is used to load 5 integer words (designated as integer D(5)) with the receiver outputs and echo time, just as the multiplexer will load the digitized outputs of the receiving equipment into 5 words which are then written as 36 bit words on tape by the Kennedy 1610 tape deck.

Each of these 5 words may be listed for checking, if the option is specified, as 5 octal words. The 5 data words comprising the simulated echo are finally written into FASTRAND file FILE1 (Unit 16) by a call to

SUBROUTINE NTRAN

NTRAN is a UNIVAC 1108 library routine, which suspends the normal FØRTRAN input/output, and enables writing of words in blocks of size controlled by the argument list specification. Here, 5 words, followed by an inter record gap are written, corresponding exactly to the single (tape) record per echo generated at the receiving site. Thus the FASTRAND file FILE1 becomes the input unit to be attached to the data reduction program DECØDE, which normally performs the first stage of processing of the real data tapes.

Also under option control are the writing of a FASTRAND file FILE2, in a binary format appropriate for direct input to programs GRØVES or ERG, and the punching of BCD data cards, one per echo, suitable for input to the appropriate LØADIT series program.

The above sequence is repeated, simulated echo by simulated echo, until the specified number of simulated echoes has been produced. The output files are then closed, the output file statistics are listed, and execution is terminated.

Section III. The Raw Echo Data Tape Reduction Program DECØDE

Introduction

The program DECØDE is an adaptation of the University of Adelaide Physics Department Program 1190A. DECØDE uses as input the data tapes written by the Kennedy 1610 tape deck at the receiving site, (or the simulated echo data output from METEØR), decodes the data and produces a listing and a FASTRAND file in a format suitable for input to the subsequent analysis programs GRØVES or ERG. The program decodes the 5 36 bit words in each record (each meteor produces 8 16 bit words, and 13 4 bit words, which are packed into 5 36 bit words), validates the echo by checking the consistency of the doppler frequency, and the echo range, and calculates the direction cosines of the echo arrival angle, and the height of the reflection center.

Normally echoes within a few degrees of the horizon, and those with heights outside the interval 70 to 120 km are rejected, but these options may be suppressed. Printed output is blocked in groups of 5 echoes, one per line, with 40 echoes to a page.

The U1108 FORTRAN PROGRAM DECØDE

Program elements are detailed in the sequency in which they are called during a run. The elements linking the subroutines constitute the

MAIN PRØGRAM.

After initialization the first data card, punched with the year of echo data tape to be processed, is read and immediately printed. Then follows reading of the card punched with the header information, which is printed by a call to

SUBROUTINE PAGE

Subroutine PAGE is a utility routine, which, on the first call, turns the page, numbers it, and prints the header information.

PAGE also counts lines of output, leaving a blank line after every 5 lines of output data, and turning the page after listing 40 lines of echo output card images.

MAIN then reads the input file names corresponding to FILEIN, and the output file name FILØUT, and prints these out.

Next, the FASTRAND file FILØUT (Unit 16) is labeled with a BCD image of the header card. Then the program options, the echo count number to be attached to first echo, the error limits in the determination of the echo arrival angle (in decimals of a wavelength, usually ≤ 0.1), the system delay factors (related to the receiving site digitization electronics, and normally 0) and 500 minus the number of ambiguous echoes to be tolerated before exit (normally NBIT = 0), are read, and printed. Then the count factor for scaling the data (the number of clock counts per second, normally 15000) is read and, after conversion to the number of counts corresponding to the period of the doppler appropriate to a line of sight drift of 1 meter sec^{-1}, normally 69231, is printed. A call to

SUBRØUTINE SITE

continues initialization, with the direction finding antenna corrections (as determined by calibration), the factors pertaining to the system axes and transmit/receive site separation, and the time correction factor, local to local mean solar, being tabulated, and written out.

The first echo is then read from the tape FILEIN by a call to

SUBRØUTINE READER

which increments the echo count by 1, zeroes not only the locations to be filled by the echo tape read, but also 5 word blocks on each side of these locations, and reads a five word record by a call to

SUBRØUTINE NTRAN

a UNIVAC 1108 library routine, which temporarily disables the FØRTRAN EXECUTIVE and enables one non-standard echo data tape 5 word record to be read from tape FILEIN (Unit 17) and stored as array D. This routine also senses a read redundancy or an end of file record.

READER then tests for

1. a redundancy - resulting in an error message, an IPAR counter increment and a return to the MAIN PRØGRAM with MISS = 1 if IPAR > 50, otherwise a return to the first statement of READER

   or

2. an end of file - resulting in a printout of the last record read, and a return to the MAIN PRØGRAM with MISS = 2.

Otherwise, READER then proceeds to unpack the 5 word array D into the variables MA, MB, MC, MD corresponding to the phase differences between the various receiver outputs (see Section II. page 8, SUBRØUTINE ECHODF for a definition of these variables) and the two measures of the absolute values of the doppler period MWAVE1 and MWAVE2.

A check is then made on the consistency of these two measures of the line of sight dopplers - if inconsistent to 20% or more an error message is printed and control proceeds as for a read redundancy, with NBIT rather than IPAR incremented.

Otherwise READER continues unpacking, producing the two measures of RANGE, MRNGE1 and MRNGE2, which are converted to approximate ranges in kilometers; if less than 65 km (Meteor echoes are very seldom recorded below an altitude of 65 km - echoes corresponding to lower altitudes usually result from aircraft) or inconsistent to 4 kilometers, a message is printed, and control proceeds as for a read redundancy, again with NBIT rather than IPAR incremented. Range < 65 Km will be accepted if option specified.

Otherwise, READER proceeds to unpack the timing words, producing year, day, of year, hour, and minute at which the echo was recorded. The time is then corrected to local mean solar time, and the resultant year day is then converted to month and day by a call to

SUBROUTINE MØNDAY

which produces both an integer month MØ and a hollerith month MØN (and works for all years, both ordinary and leapyears).

MAIN then checks MISS, to see if an END ØF FILE or a bad data tape has been detected. If so, control is transferred to STATEMENT NO. 200, and the program is terminated as detailed at the end of this section. Otherwise, MAIN then determines the local mean solar "clock" time by appropriate addition of the hours and minutes (24 hour clock), and then proceeds to the unravelling of the direction cosines of the arrival angle of the echo at the receiving site.

First, the system delay factors are applied to each phase count to establish a common reference. Then the integer phase counts are floated, and divided by the doppler count to give relative phases on the interval 0,1.

After ensuring that the relative phases do lie in 0,1, the program takes a guess at the direction cosines as measured at antennae 1 and 3, and tests their consistency by comparing the guess with the difference between the phases measured at antennae 4 and 5 by a call to

SUBRØUTINE SØLVE.

The key to acceptance or rejection of the chosen direction cosines (the final values may not be decided upon until several "guesses", involving sign changes and angle complements, have been tested by SØLVE) is the value of error to be tolerated (which was initially read from the control options card - see page 93 and Appendix III). The first two possible calls to SØLVE test the consistency of the relative magnitudes of the phases at each of the 5 direction finding antennae. An inconsistency at this point will result in an error message directing NØ CHECK FOR X*. The next four calls to SØLVE determine in which quadrant the echo lies. Of course, as soon as SØLVE returns cosines within the limits of the desired error, the remaining calls to SØLVE are redundant, and are bypassed. Similarly, if an irreconcilable inconsistency arises at any point, messages of the type NO CHECK FOR C will arise*. The occurrence of FAULT FOR NSTAT = message cannot arise logically - a program card misread on compilation or a machine fault would have to be involved.

*If an inconsistency has been detected, a second pass is made, with the sign of the velocity changed. If still inconsistent, the Table of Diagnostic Messages (see listing of PRØGRAM DECØDE. MAIN) will be accessed, a diagnostic message will be printed, a check will be made on printer blocking by a call to

SUBRØUTINE PAGE

and control will be returned to STATEMENT NO. 1 - CALL READER resulting in the reading of a new echo from the data tape, and subsequent processing as outlined above.

Otherwise, the validated direction cosines will be corrected for deviations from the ideal direction finding antenna pattern (as measured by an antenna calibration). If the option is specified, the cosine of the zenith angle is calculated, and echoes within a few degrees of the horizon (and therefore probably spurious) are elimінted. After calculation of the true midpoint range (Appendix IIA), the direction cosines of acceptable echoes are then referred to axes translated to the transmit/receive system midpoint, and rotated to true north-south and east-west. The vertical direction cosine is then calculated, and from this, and the range, the echo height is calculated, including an Earth curvature correction based on the approximation

$$\text{HITE} = Z + \frac{x^2 + y^2}{2R}$$

where Z is the flat Earth height and x and y are the coordinates of the point vertically below the echo center.

Next follows the calculation of the local mean solar time to the nearest hour (echoes occurring 30 minutes before the hour to 30 minutes after the hour are the major contributors to winds measured on the hour in simple "quick look" type analyses that can be applied to the raw data), and the "level" appropriate to 10 KM height blocks centered on 80, 90, and 100 KM (again, for "quick look" analyses). Similarly "quick look" type velocity components are also calculated, in which the wind is assumed to be purely horizontal.

Since subsequent analysis programs require a velocity convention which defines a line of sight drift away from the system axes origin as positive, the sign of the drift velocity is changed.

Next, FILØUT (Unit 16) is loaded, in binary, with the data pertaining to the echo. This data is also listed, with a call to

SUBROUTINE PAGE

keeping a check on the output blocking, and control is then returned to STATEMENT NO. 1 - CALL READER for further processing of the input data tape.

As detailed earlier, detection of an END ØF FILE or bad data on the echo data tape FILEIN results in a transfer of control to STATEMENT NO. 200. An all zero record (a "flag" record) is written on FILØUT, and the file is closed.

The output file statistics are then calculated and listed, both input and output files are rewound, and the program terminated.

Addendum: To conserve output, a sixth option, suppressing diagnostic printouts, can be specified on the options card.

A seventh option suppresses printout of data tape read diagnostics. With the station in routine operation, trouble was experienced in reading some data tapes - this was cured by incorporating a block move branch, which searches for the next inter record gap if five successive reads are bad; prints a P (parity error) or B (bad record) in column 130 of the output listing for each block move. A dirty head (or tape) can lead to erroneous end of file reads. Only a double end of file will terminate execution.

Section IV. The Series of Programs LØADIT

The LØADIT series programs are simple FORTRAN routines which load a FASTRAND file compatible as input to the programs GRØVES and ERG, with echo by echo data produced by radio meteor stations other than that operated by Georgia Tech. They are specific to each source, and process either tapes or cards provided by (or punched from listings provided by) other stations participating in the Global Radio Meteor Wind Studies Project.

In some cases, the program performs only a change in formatting, all the variables for input to GRØVES or ERG being specified in the input data list. Other versions are required to convert some listed parameters - for example, several stations use echo arrival azimuth and elevation, which need to be converted to direction cosines. Practically all data times need to be converted to local mean solar, which is more meaningful in calculations of tidal phase. In some cases, actual character transformations have to be performed - as one example, IBM 360 series plus signs need to be converted to U1108 code.

A program in this series has also been used to load cards punched by the echo data simulation program METEØR, for test runs of GRØVES and ERG which involved modification of the input data for each of several runs (such as decreasing the sample size by pulling every second card of the input data, for example).

Section V. The Height/Time Wind Variation Program GRØVES

Introduction

One of the most significant events in the history of radio meteor wind measurement was the appearance, in the Journal of Atmospheric and Terrestrial Physics, Volume 16, (1959), pp. 344-356, of a paper by G. V. Groves entitled "A Theory for Determining Upper Atmosphere Winds from Radio Observations on Meteor Trails".

While in Australia for the launching of some Skylark vehicles from Woomera as part of the joint United Kingdom/Australia space research effort, some problems developed with the experiments and Groves found himself virtually stranded down under for some 3 months. In that time, he became aware, in great detail, of the problems being encountered by the Radio Meteor Group of the Physics Department of the University of Adelaide. This pioneer group, established in 1950 by the then Professor L. G. H. Huxley (now Sir Leonard), and being led by Dr. W. G. Elford, had very quickly realized, from the data being gathered, that considerable variation of the wind pattern with height (over the 75 to 105 km range being sampled) existed, and had evolved desk machine calculation techniques to illustrate this variation by arbitrarily stratifying the region into 10 km slabs, centered on 80, 90, and 100 km altitudes. Each slab was independently analysed for the prevailing, 24 hour and 12 hour variations known to be common in this region.

As well as being a good physicist, Groves was also an astute applied mathematician, and he developed an analysis in which measurements at all times and all heights were connected by a model which assumed a polynomial variation with height, and the customary prevailing, 24 and 12 hour winds, with an 8 hour component thrown in for good measure (in fact, any number of higher order harmonics could be included by simply continuing the Fourier series). The coefficients of this model were then determined, using the method of least squares, by matching the data against the model. Preliminary analyses applied to actual data yielded results which were most encouraging, producing as they did practically the same winds at 80, 90, and 100 kilometers as produced by the arbitrary "slab" method, while providing detailed profiles over the 80 to 100 km height range. Because all reductions were still being done by hand, only simple models could be tested, but the method obviously had great possibilities.

In 1960, the Weapons Research Establishment (an arm of the Australian Defence Scientific Service of the Commonwealth Department of Supply) installed an IBM 7090 computer, which was made available for use by the University of Adelaide. In 1963, the team of Elford and Roper programmed the Groves' analysis (program GRØVES), and its logical extension, the periodogram analysis ERG described in Section VI.

Execution time for a standard model (63 coefficients) is approximately 60 seconds per 1000 echoes on the Georgia Tech UNIVAC 1108.

THE U1108 FORTRAN PROGRAM GRØVES

Program elements are detailed in the sequence in which they are called during a run. The elements linking the subroutines constitute the MAIN PRØGRAM.

The program first interrogates the machine to determine the date on which the program is being run by a call to

SUBROUTINE ERTRAN

a library utility routine which performs several functions according to its first argument. In the present use, it returns a six character hollerith word containing the month, day, and last 2 digits of the year. This word is converted to three integers and stored as DATE, by use of the system function DECØDE. A call to

SUBROUTINE MØNTH

Converts the integer DATE (1) into an alphabetic abreviation for the month. This is done so that the output listings can be identified as having been run during a particular month without the confusion that exists in purely numeric dating (other countries usually use the sequency day, month, year in numeric dating).

After initialization, the first record of the input data file (Unit NTAPE), which contains the output from either PROGRAM DECØDE or one of the "LOADIT" series program, is read.

Next, the data card determining the interval of data to be read from the echo data input file is read. If an END ØF FILE is sensed, an error message including

CONTINGENCY LEVEL 1

is printed, and execution terminated.

Otherwise, the data interval is checked for consistency; if inconsistent, an error message including

CONTINGENCY LEVEL 2

is printed, and execution terminated.

If the data interval is consistent, the starting date and end date are separated into year, month, and day. If the data interval card is blank, no separation is performed. All data in the echo data file will be read at the appropriate time. To obviate confusion in data reporting and exchange, the month is expressed in an alternate hollerith (alphabetic) form by additional calls to

SUBROUTINE MØNTH.

Then MAIN reads the six cards which determine the parameters to be used in the model height/time fitting process. If the vertical fitting parameters have been set negative, this indicates that the vertical wind is to be considered zero at all times, i.e. all winds are horizontal. Additional fitting parameters are calculated during this read sequence.

A check is next made on the number of parameters N specifying the total model. An error message is printed if N is too large (> 100), and execution is terminated.

Next, the echo data is processed; echoes are read one at a time; each is checked for validity (whether a read redundancy, a terminal "flag" echo, or end of file - appropriate error messages are printed), then the echo height is checked - if outside the model height range, a new echo is read. Then the echo date is checked, to ensure that it lies within the interval to be processed. If not, a new echo is read; otherwise, the valid echo count (M) is incremented by one. If this is the first echo accepted, the commencement of the interval is redefined. This ensures that the start of the data interval is available for eventual printout if a blank card has been used to specify "all data in echo data file to be processed".

The time of occurrence (to the nearest minute) is then calculated as a function of the input periodicity, and expressed in radians. Sines and cosines of this period, and the appropriate number of harmonics specified in the model, are then calculated.

The next step is to tabulate the echo in height and time for eventual output in the echo rate map. Then the direction cosines are expressed as the variables of the subsequent reductions, converted, if necessary, if the winds are to be considered horizontal.

The normalized height S of the echo is then calculated (all polynomial height profile coefficients relate to the normalized height parameter S). Then the contributions of this echo to the constant (with time) coefficients of the north-south, east-west and vertical wind profiles are calculated, followed by the contribution to the time varying coefficients. The contributions of this particular echo form the coefficient column D, which is then summed into the total contribution column P, and the array Q. Each echo is weighted by a factor depending on the echo arrival angle and the relative magnitudes of the contributions to the orthogonal height profiles.

Control then returns to STATEMENT NO. 3, and another echo is read from the input file, and similarly processed.

Reading of a zero record, or end of file, in the echo data, transfers control to STATEMENT NO. 100, which calls

SUBROUTINE PAGE .

PAGE is a utility routine, which turns the output page, and prints, as a header at the top of each page, the label read from the echo data input tape, the date on which the program is being run, and the page number.

Next, the end of the actual echo data processing interval is defined, and MAIN prints the two year/month/day variables denoting the dates between which the wind is being determined, followed by a list of the input parameters of the model being fitted, and the number of meteor echoes contributing to the analysis. After another call to

SUBROUTINE PAGE

MAIN proceeds to output the echo rate map (the height/time statistics of echo occurrence). A check is then made of the total number of echoes M contributing to the analysis - if this is less than 120, a message is printed

CONTINGENCY LEVEL 3

and execution is terminated.

If $M > 120$, then matrix Q is copied into matrix A, and A is inverted by a call to

SUBROUTINE MATSIN,

a matrix inversion routine which will accept matrices of order up to 100×100. MATSIN is a standard pivotal element reduction. Upon completion of the inversion, $R = A^{-1}$, stored in A, control returns to MAIN, which immediately tests the magnitude of the determinant, to ensure that the matrix Q was nonsingular. If the determinant is less than 10^{-12}, an error message is printed

CONTINGENCY LEVEL 4

and execution is terminated.

If not, then the coefficients of the height/time wind model , column AC, are calculated from the weighted echo data column P and the inverse matrix R. Then an estimate of the error in each coefficient AC(K) is calculated from AC, P, and Q, and the number of "independent" samples $M - N$, where M is the number of meteors contributing to Q, and N is the order of Q (i.e. the number of coefficients in the model). A check is made on the sign of the square of the error, to obviate a negative SQRT argument. The sign of the argument is attached to the square root of the absolute value. A negative error is an indication of instability in the matching of data to the model, and a different set of coefficient parameters (fewer) should be specified and the program rerun.

Output is preceded by a call to

SUBROUTINE PAGE

which turns the output page, numbers it, and prints HEADER, SOURCE, and

DATE of run information at the top.

After the matrix determinant is listed (since this is a very large number, it is calculated and printed as $\log_{10}$), the model coefficients (AC), and the error in each, are printed - 45 to a page. If more than 45 coefficients are involved, the page is turned and headed by a call to PAGE, and the additional coefficients printed. The coefficients AC are also punched out, 8 to a card - always 13 cards.

If the fundamental analysis period has been specified as 24.0 (which is usually the case) then the hour by hour winds in the east/west, north/south and vertical directions for each hour of the day are calculated and listed by a call to

SUBROUTINE DIANA.

DIANA, which has access to all the model input parameters and output coefficients via CØMMØN, reconstitutes height time wind profiles, hour by hour, in 2 km height steps over the height range analyzed. Suitable headers and scales are formatted and listed, with output of each wind component organized by appropriate calls to PAGE. (The height/time profiles thus listed are reconstituted from the model profile coefficients only, and normally consist of the sum of the prevailing 24, 12, and 8 hour components).

After returning to MAIN, the amplitude of the prevailing wind components, and the amplitudes and phases of each of the periodic components modeled, are calculated and printed out as a function of height (2 km intervals) by a call to

SUBROUTINE VARY

Again, all the model parameters and coefficients are accessible to VARY through CØMMØN. Suitable headers and scales are formatted, and output of the appropriate components is again organized by calls to PAGE.

On the return to MAIN, execution is terminated.

Section VI. The Wind Periodogram Analysis Program ERG

Introduction

The basic wind periodogram analysis program ERG was written by Elford and Roper, of the University of Adelaide Physics Department, in 1963 as an extension of the program GRØVES, and was initially run to demonstrate the validity of the choice of tidal periods (24, 12, and 8 hour) usually specified in the Groves' analysis. While there was little doubt of the reality of the 24 and 12 hour components, their relationship to the irregular wind "background", and the relative importance of 8 hour and 6 hour components was not well established. ERG uses the same echo data input file as GRØVES, and fits height polynomials to a single periodicity on each scan through the data. Execution time is approximately 10 seconds per 1000 echoes per period.

The U1108 FØRTRAN program ERG

Program elements are detailed in the sequence in which they are called during a run. The elements linking the subroutines constitute the MAIN PROGRAM.

The program first interrogates the machine to determine the date of the run by a call to

SUBROUTINE ERTRAN

a library utility routine which performs several functions according to its first argument. In the present use, it returns a six character hollerith word containing the month, day, and last two digits of the year. This word is converted to three integers and stored as DATE, by use of the system function DECØDE. A call to

SUBROUTINE MØNTH

converts the integer DATE(1) into an alphabetic abbreviation for the month. This is done so that the output listings can be identified as having been run during a particular month without the confusion that exists in purely numeric dating (other countries usually use the sequence day, month, year in numeric dating).

After initialization, the first record (label) of the input data file (Unit 4) which contains the output from either PRØGRAM DE¢ODE or one of the "LOADIT" series programs, is read.

Next, the data card determining the interval of data to be read from the echo data input file is read, and checked for consistency. If inconsistent, control is transferred to

STATEMENT NO. 1102

and a call is made to

SUBROUTINE PAGE

a utility routine which turns the page, heads it with the information in the echo data tape label, prints the date of the run, and numbers the page (and prints other appropriate header information, depending on the nature of the second argument). Upon return to the MAIN PRØGRAM, an error message involving Q(0, 0) is printed, and execution terminated.

If the data interval is consistent, a check is made on whether or not a blank card has been read (such a read results in all data in the echo data file being processed).

Then the model parameters are set up in MAIN, with the only externally determined parameters being the height range, read from one card, and checked for consistency (an error message involving

HEIGHT RANGE

is printed if MIN. GT. MAX or MAX - MIN. GT. 30.), the profile specification polynomials (one more card) and the spectrum interval parameters (one more card). The spectrum interval and step within that interval are then checked for consistency. If inconsistent, a transfer is made to

STATEMENT NO. 333

an error message is printed, and execution is terminated.

If the spectrum interval parameters are deemed consistent, the number of passes through the data (the number of periods to be fitted), appropriate program scan parameters and, if this is the first run through the program, the output height column, are defined.

Next, the number of model parameters (coefficients) N is tested. If an unrealistic model (too few or too many parameters) has been specified, a call is made to

SUBROUTINE PAGE

and an diagnostic

N = , EXECUTION TERMINATED

is written, and execution terminated.

Otherwise, all the parameters appropriate to the model indexing are calculated, and the echo data file positioned for reading.

On this first run through the program, the echo data is read, echo by echo and, if it lies within the appropriate data interval to be processed, and within the height range specified, and the data array dimensions (5000) are not exceeded, the relevant parameters are stored in arrays.

If, during the course of reading the data, the month changes, then continuity of the data interval is maintained by adding the day of the last record read to all subsequent days. This means that, if more than one months data is to be processed, it is imperative that at least one acceptable echo be recorded on the last day of every month occurring before a month change.

The DAY of the first accepted echo becomes the start day STRTDA, in case either the specified STRTDA was zero (all data in the file to be read) or no data was recorded on the STRTDA requested. Once all the data requested has been filed in core, the DAY of the last acceptable echo becomes the end day ENDDAY (for reasons as for STRTDA above).

The starting date and end date are each separated into year, month, and day. Again, to obviate confusion in data reporting and exchange, each month is expressed in an alternate hollerith (alphabetic) form by additional calls to SUBROUTINE MØNTH

On return to MAIN, the first record (the label) is written on the output file (Unit 16); it contains all the data necessary to identify the subsequent records, and, in particular, contains the input parameters required by the spectrum transform program being developed. This output record is counted, and the program then proceeds to scan the data in core, just as the program GRØVES scans its input file, but fitting only one fourier component on each scan, starting with the lowest frequency (usually specified as 0.5 cycles per day, although any starting frequency consistent with the data length can be specified on the spectrum interval card) and incrementing the frequency (usually 0.05 or 0.1 cycles per day, again dependent upon the data interval) after each scan until the highest frequency (usually 4.0 cycles per day, but dependent on the echo rate) is reached.

The D and P columns, and matrix Q are calculated as in GRØVES, but the matrix inversion SUBROUTINE MATSIN proceeds by a method of Gaussian elimination, destroying the augmented matrix A in the process. The singularity of the matrix is checked, and a diagnostic is printed if any diagonal element is less than 10^{-12}, and execution is terminated.

If the inversion is stable, then the coefficient column AC(K) is evaluated, together with the appropriate error column (as in GRØVES, a negative error is indicative of fitting problems, and fewer coefficients should be specified).

On the first scan, preliminary output is produced by a call to

SUBROUTINE PAGE

and printing of parameters pertaining to the data, and the model being fitted. In contrast with the program GRØVES, no echo rate map, or hour by hour wind profiles (as produced by GRØVES . DIANA) are output, but the coefficient column AC(K) and the associated coefficient errors are output after a call to

SUBROUTINE PAGE

Another call to

SUBROUTINE PAGE

is followed by a call to

SUBROUTINE VARY

which calculates the prevailing components, and the amplitude and phase of the north-south, east-west, and vertical components of the frequency just fitted, for each two kilometers of height within the height range specified. These are printed out, and also written as three separate records on the output file (Unit 16), each record being counted individually.

If the highest frequency specified has not been reached, control is returned to

STATEMENT NO. 998

where the scanning frequency is incremented, the data scanned again, and the height profiles at the new frequency fitted.

When the spectrum scan is complete, an all zero "flag" record is written on the output file (Unit 16) (this record is also counted).

A check is made to see if, perhaps, the data is to be scanned over another spectral interval (i.e. if IBIT is set to 1); if so, another spectrum interval card is read (from input Unit 5) and the scanning and output processes repeated; if not, then the output file (Unit 16) is closed and rewound, the number of records written in this file is printed, and execution is terminated.

APPENDIX I

LISTINGS OF THE UNIVAC 1108 PROGRAMS

```
 C      PROGRAM LOCATE


C
C       ESTABLISHES SITE CONSTANTS FOR USE BY 'METEOR' AND 'DE
       *CODE'
C
C       DECK IS LOADED AS FOLLOWS
C       MAIN PROGRAM
C       SUBROUTINES COORD
C                   TOPO
C
C       NOTE - WEST LONGITUDES AND SOUTHERN LATITUDES ARE NEGA
       *TIVE
C       SIGN IS ATTATCHED TO DEGREES ONLY, NOT TO MINUTES AND
       *SECONDS.
C
C
        REAL NSSHFT
C
C       CONSTANTS
C
        SIXTY=60.0
        SIXTY2=SIXTY*SIXTY
        DEGRAD=0.01745329
C
C       TRANSMITTER LAT/LON
C
C
        TLATD=33.0
        TLATM=46.0
        TLATS=19.0
        TLAT=(TLATD+SIGN(TLATM/SIXTY+TLATS/SIXTY2,TLATD))*DEGR
       *AD
        TLOND=-84.0
        TLONM=23.0
        TLONS=46.0
        TLON=(TLOND+SIGN(TLONM/SIXTY+TLONS/SIXTY2,TLOND))*DEGR
       *AD
C
C       HEIGHT OF TRANSMITTING ANTENNA ABOVE SEA LEVEL (FEET)
C
        TH=1025.0
C
C       RECEIVING SITE LAT/LON
C
        RLATD=33.0
        RLATM=57.0
```

```
C      PROGRAM LOCATE

       RLATS=56.0
       RLAT=(RLATD+SIGN(RLATM/SIXTY+RLATS/SIXTY2,RLATD))*DEGR
      *AD
       RLOND=-84.0
       RLONM=13.0
       RLONS=07.0
       RLON=(RLOND+SIGN(RLONM/SIXTY+RLONS/SIXTY2,RLOND))*DEGR
      *AD
C
C      HEIGHT OF RECEIVING ANTENNAE ABOVE SEA LEVEL (FEET)
C
       RH=1088.0
C
C
C      ESTABLISH GEOCENTRIC COORDINATES
C
       CALL COORD(TLAT,TLON,TH,TX,TY,TZ,TEARTH)
       CALL COORD(RLAT,RLON,RH,RX,RY,RZ,REARTH)
       EARTHR=(TEARTH+REARTH)/2.0              @ KILOMETERS
C
C      PERFORM TOPOCENTRIC TRANSFORMATIONS TO CALCULATE
C      TRANSMITTER/RECEIVER SITE SEPARATION, AND
C      BEARING OF RECEIVING SITE FROM TRANSMITTER
C
       CALL TOPO(TX,TY,TZ,RX,RY,RZ,X,Y,Z,RCOR,AZ,EL)
C
C      ROTATION FACTORS, SYSTEM AXES TO NORTH - SOUTH, EAST -
      * WEST
C
       COSROT=COS(AZ)
       SINROT=SIN(AZ)
C
C      MIDPOINT TRANSLATION FACTORS     (KILOMETERS)
C
       EWSHFT=-X/2.0
       NSSHFT=-Y/2.0
C
C      DF DIRECTION COSINE CORRECTIONS
C
       ELCOR=0.0
       EMCOR=0.0
C
C      LOCAL MEAN SOLAR TIME CORRECTION    (MINUTES)
C
       ITCOR=-37
```

```
 C      PROGRAM LOCATE


C
C
C      LIST SITE FACTORS
C
       WRITE(6,1000) TLATD,TLATM,TLATS,TLOND,TLONM,TLONS,RLAT
      *D,RLATM,RLAT
      1S,RLOND,RLONM,RLONS,RCOR,EWSHFT,NSSHFT,ELCOR,EMCOR,COS
      *ROT,SINROT,
      2ITCOR,EARTHR
 1000 FORMAT(/1X,'TRANSMITTER LATITUDE', 3F4.0,' LONGITUDE',
      * 3F4.0/
      1' RECEIVER    LATITUDE' , 3F4.0,' LONGITUDE',3F4.0/' T
      */R SEPARATIO
      2N',F8.3,'KM'/' MIDPOINT COORDINATES',2F8.3/' RECEIVING
      * SITE ANTENN
      3A CORRECTIONS, L',F8.4,' M',F8.4/' AXIS ROTATION COS',
      *F8.4,'  SIN'
      4,F8.4/' LOCAL MEAN SOLAR TIME CORRECTION',I4,' MINUTES
      *,','   MEAN
      5EARTH RADIUS',F8.3,' KM')
C
       STOP
       END
```

```
      SUBROUTINE COORD(RL,RN,H,X,Y,Z,R)
C
C     REFERENCE OUTLINE FOR TOPOCENTRIC COMPUTATIONS - G.D.
     *MORRISON
C
C     THIS SUBPROGRAM ACCEPTS
C     LATITUDE  (RADIANS)  (NORTH-POSITIVE)
C     LONGITUDE  (RADIANS)  (EAST-POSITIVE)
C     HEIGHT ABOVE LOCAL RADIUS  (FEET)
C     IT RETURNS THE GEOCENTRIC COORDINATES
C     X,Y,Z  -  SAME COORD. SYSTEM (KM)
C     R  -  RADIUS AT THAT POINT
C     CALCULATIONS ARE MADE ASSUMING OBLATE SPHEROID
C
C     EQUATORIAL RADIUS  (KM)
      A=6378.16
C     POLAR RADIUS   (KM)
      B=6356.7747
C     FEET-KILOMETER
      C=1./3280.840
      XK1=(B/A)**2
C     GEOGRAPHIC LAT TO GEOCENTRIC LAT
      PHI=ATAN(XK1*TAN(RL))
      XK2=1.-XK1
      R=H*C+B/SQRT(1.-XK2*COS(PHI)**2)
      Z=R*SIN(PHI)
      Y=R*COS(PHI)*COS(RN)
      X=R*COS(PHI)*SIN(RN)
      RETURN
      END
```

```
      SUBROUTINE TOPO(X1,Y1,Z1,X2,Y2,Z2,X,Y,Z,D,TH,ALPH)
C
C      REFERENCE OUTLINE FOR TOPOCENTRIC COMPUTATIONS - G.D.
     *MORRISON
C
C      THIS SUBPROGRAM ACCEPTS THE GEOCENTRIC COORDINATES
C      OF AN ORIGIN-SITE PAIR SYSTEM
C      X1,Y1,Z1 - ORIGIN GEOCENTRIC COORDINATES
C      X2,Y2,Z2 - SITE GEOCENTRIC COORDINATES
C
C      IT RETURNS THE TOPOCENTRIC COORDINATES:
C      X = EAST  (KM)
C      Y = NORTH  (KM)
C      Z = ZENITH  (TRUE)  (KM)
C      D = THE STRAIGHT LINE DISTANCE  (KM)
C      TH = THE AZIMUTH ANGLE  (COMPASS)  (RADIANS)
C      ALPH = THE DEPRESSION ANGLE FROM PLANE OF ORIGIN TO SI
     *TE
C            POSITIVE MEASURED DOWNWARD OUT OF PLANE (RADIAN
     *S)
C
      P2I=2.*3.1415926535
      ZN=6356.7747
C
C      VECTOR R
C
      RI=Y1*(X2*Y1-X1*Y2)-Z1*(Z2*X1-Z1*X2)
      RJ=Z1*(Y2*Z1-Y1*Z2)-X1*(X2*Y1-X1*Y2)
      RK=X1*(Z2*X1-Z1*X2)-Y1*(Y2*Z1-Y1*Z2)
C
C      VECTOR T
C
      TI=-X1*Z1*ZN
      TJ=-Y1*Z1*ZN
      TK=Y1*Y1*ZN+X1*X1*ZN
C
C      UNIT VECTOR R
C
      RN=SQRT(RI**2+RJ**2+RK**2)
      RI=RI/RN
      RJ=RJ/RN
      RK=RK/RN
C
C      UNIT VECTOR T
C
      TN=SQRT(TI**2+TJ**2+TK**2)
```

```
      SUBROUTINE TOPO(X1,Y1,Z1,X2,Y2,Z2,X,Y,Z,D,TH,ALPH)


      TI=TI/TN
      TJ=TJ/TN
      TK=TK/TN
C
C     CROSS PRODUCT  R TO T
C
      CST=RI*TI+RJ*TJ+RK*TK
      TH=ACOS(CST)
C
C     RECOMPUTE LONGITUDES FOR SIGN DETERMINATION
C
      R1=SQRT(X1**2+Y1**2+Z1**2)
      P1=ASIN(Z1/R1)
      RN1=ACOS(Y1/(R1*COS(P1)))
      R2=SQRT(X2**2+Y2**2+Z2**2)
      P2=ASIN(Z2/R2)
      RN2=ACOS(Y2/(R2*COS(P2)))
      IF(RN2.GT.RN1)TH=P2I-TH
C
C     LINE FORMULAE
C
      T=1.-(X1*X2+Y1*Y2+Z1*Z2)/(X1**2+Y1**2+Z1**2)
      XR=X1*T+X2
      YR=Y1*T+Y2
      ZR=Z1*T+Z2
      R=SQRT(((XR-X1)**2)+((YR-Y1)**2)+((ZR-Z1)**2))
C
C     TOPOCENTRIC COORDINATES X,Y
C
      X=R*SIN(TH)
      Y=R*COS(TH)
      AI=X1/R1
      AJ=Y1/R1
      AK=Z1/R1
      CI=X2-X1
      CJ=Y2-Y1
      CK=Z2-Z1
      CN=SQRT(CI**2+CJ**2+CK**2)
      CI=CI/CN
      CJ=CJ/CN
      CK=CK/CN
      CSA=0.
      CSA=CI*AI+CJ*AJ+CK*AK
      ALPH=ACOS(CSA)-P2I/4.
      Z=-R*TAN(ALPH)
```

```
SUBROUTINE TOPO(X1,Y1,Z1,X2,Y2,Z2,X,Y,Z,D,TH,ALPH)


D=SQRT(X**2+Y**2+Z**2)
RETURN
END
```

MAIN PROGRAM (METEOR)

```
C      PROGRAM METEOR    GEORGIA TECH U1108 FORTRAN V          0
      *29 PUNCH
C
C      DATA SIMULATOR FOR GT METEOR WIND SYSTEM
C      PRODUCES OUTPUT REQUIRED TO CHECK OUT ALL REDUCTION
C      AND ANALYSIS PROGRAMS.
C      GENERATES 5 WORD BLOCKS FOR INPUT TO PROGRAM 'DECODE'
C                BINARY CARD IMAGES FOR INPUT TO 'GROVES' OR
      *'ERG'
C                BCD CARDS FOR INPUT TO 'GROVES' OR 'ERG' VIA
      * 'LOADIT'
C                LISTING OF BCD CARDS (WHETHER PUNCHED OR NOT
      *, IF DESIRED)
C
C      DECK IS LOADED AS FOLLOWS -
C      MAIN PROGRAM
C      SUBROUTINES ADATA
C                  NOISE
C                  VNOISE
C                  WIND
C                  ECHODF
C                  NORMAL
C     @XQT
C      HEADER CARD                                              FO
      *RMAT 12A6,2A4
C      DATA CARD, PUNCHED AS FOLLOWS
C      COLUMN  PUNCH            GENERATES
C         1      1      DATA INPUT FILE FOR 'DECODE'
C         2      1      LISTING OF 'GROVES/ERG' INPUT
C         3      1      DATA INPUT FILE FOR 'GROVES/ERG'
C         4      1      BCD CARDS FOR INPUT TO 'LOADIT'
C         5      1      ADD NOISE (RMSVEL) TO DOPPLER VELOCITY
C         6      1      ADD NOISE (RMSPH) TO RECEIVER OUTPUT P
      *HASES
C         7      1      WRITE OUT 'DECODE' INPUT RECORDS IN OC
      *TAL
C         8      1      RESTRICT HEIGHT RANGE TO 77 TO 104 KIL
      *OMETERS
C         9      1      SET BOTH DOPPLERS EQUAL (MWAVE1=MWAVE2
      *)
C        10      1      SET BOTH RANGES EQUAL  (MRNGE1=MRNGE2)
C       A ZERO IN ANY OF THE ABOVE COLUMNS WILL SUPPRESS THAT
      * OPTION - NB BLANKS
C       WILL NOT SUFFICE.    ***** AGAIN, BLANKS WILL NOT SUFF
      *ICE *****
```

```
C       11-20  NUMBER OF ECHOES TO BE SIMULATED
C       21-30  RMS 'NOISE' TO BE ADDED TO DOPPLER VELOCITY (R
     *EQUIRES 1 IN COL 5)
C       31-40  RMS 'NOISE' TO BE ADDED TO OUTPUT PHASES (REQU
     *IRES 1 IN COL 6)
C                                                            FO
     *RMAT 10A1,I10,2F10.0
C      DATA CARD - NAME OF 'DECODE' INPUT FILE      FILE1   FO
     *RMAT 2A6
C      DATA CARD - NAME OF 'GROVES/ERG' INPUT FILE FILE2   FO
     *RMAT 2A6
C      EOF
C
C      UNIT  4 IS OUTPUT FILE, 'GROVES/ERG' DATA
C      UNIT 16 IS OUTPUT FILE, 'DECODE' DATA
C
       DIMENSION DMZ(5),D(5),DMZ2(5),LINK(10),SOURCE(2),HEADE
     *R(12)
C
       INTEGER DMZ,D,DMZ2,EOF
       INTEGER FILE1(2),FILE2(2),O
       INTEGER H
       REAL NSSHFT
C
       COMMON/CHUNK/ AC(70),NP,NQ,NK,NA0,NB0,NC0,NA(10),NB(10
     *),NC(10),
     1U1,V1,W1,T,Z,NANEW(10),ZMAX,ZMIN
       COMMON/COUNTR/N
       COMMON/VCOUNT/NV
C
       EOF=6HEOFEOF
       JTAPE=16
       REWIND 4
       CALL NTRAN (JTAPE,10)
C
C      CORRECTION TERMS AS USED IN DECODE
C
       EARTHR=6371.9
       ELCOR=0.0
       EMCOR=0.0
       COSROT=0.7949
       SINROT=0.6068
       EWSHFT=-8.203
       NSSHFT=-10.745
       RACOR=SQRT(EWSHFT**2+NSSHFT**2)
```

MAIN PROGRAM (METEOR)

```
      RCOR=2.0*RACOR
      ITCOR=-37
C
C     CORRECTION TERMS APPROPRIATE TO ECHO SYNTHESIS
C
      ELCOR=-ELCOR
      EMCOR=-EMCOR
      SINROT=-SINROT
      EWSHFT=-EWSHFT
      NSSHFT=-NSSHFT
      ITCOR=-ITCOR
C
      O=1HO
      ZGT=110.0
      ZLT= 70.0
      WAVEL=(30.0/32.5)*5.0*15000.0
      RLIM=416.364
      N=0
      NV=0
      NFILE1=0
      NFILE2=0
      NCARD=0
      MY=84
      MO=4
      UR=7000.
      LEVEL=6
      MX=3
      MCS=3
      RAD=0.017453293
C
C     READ HEADER CARD
C
      READ(5,999) HEADER,SOURCE
 999  FORMAT(12A6,2A4)
C
C     DETERMINE TYPE OF OUTPUT REQUIRED, AND NUMBER OF ECHOE
     *S TO BE SIMULATED
C
      READ(5,1000) LINK,NEND,RMSVEL,RMSPH
 1000 FORMAT(10A1,I10,2F10.0)
C
C     READ OUTPUT FILENAMES  (FILE1 AND FILE2)
C
      READ(5,1001) FILE1,FILE2
 1001 FORMAT(2A6)
```

MAIN PROGRAM (METEOR)

```
C
      WRITE(6,1002)
 1002 FORMAT(29H OUTPUT OPTIONS SPECIFIED ARE/1X)
      IF(LINK(1).NE.0) WRITE(6,1003) NEND,FILE1
 1003 FORMAT(5H 1.   ,I6,31H RECORDS TO BE WRITTEN IN FILE ,2
     *A6,
     122H FOR INPUT TO 'DECODE'/1X)
      IF(LINK(2).NE.0) WRITE(6,1004)
 1004 FORMAT(63H 2.           ECHO DATA TO BE LISTED IN 'GROVE
     *S/ERG' INPUT
     1 FORMAT/1X)
      IF(LINK(3).NE.0) WRITE(6,1005) NEND,FILE2
 1005 FORMAT(5H 3.   ,I6,31H RECORDS TO BE WRITTEN IN FILE ,2
     *A6,
     126H FOR INPUT TO 'GROVES/ERG'/1X)
      IF(LINK(3).NE.0) WRITE(4,999) HEADER,SOURCE
      IF(LINK(4).NE.0) WRITE(6,1006) NEND
 1006 FORMAT(5H 4.   ,I6,42H CARDS TO BE PUNCHED FOR INPUT TO
     * 'LOADIT'/1X
     1)
      IF(LINK(5).NE.0) WRITE(6,1007) RMSVEL
 1007 FORMAT(5H 5.   ,F6.0,52H METERS/SEC OF NOISE TO BE ADDE
     *D TO DOPPLER
     1 VELOCITY/1X)
      IF(LINK(6).NE.0) WRITE(6,1008) RMSPH
 1008 FORMAT(5H 6.   ,F6.3,57H OF 'WAVE' TO BE ADDED AS NOISE
     * TO RECEIVER
     1 OUTPUT PHASES/1X)
      IF(LINK(7).NE.0) WRITE(6,1009) FILE1
 1009 FORMAT(52H 7.           OCTAL REPRESENTATION OF RECORDS
     *IN FILE ,
     12A6,18H TO BE WRITTEN OUT/1X)
      IF(LINK(8).NE.0) WRITE(6,1010)
 1010 FORMAT(51H 8.           HEIGHT RANGE RESTRICTED TO 77 TO
     * 104 KM/1X)
      IF(LINK(9).NE.0) WRITE(6,1011)
 1011 FORMAT(44H 9.           DOPPLERS EQUAL:  MWAVE1 = MWAVE2
     */1X)
      IF(LINK(10).NE.0) WRITE(6,1012)
 1012 FORMAT(44H 10.          RANGES EQUAL:    MRNGE1 = MRNGE2
     * /1X)
C
      RMSVEL=10.0*RMSVEL
      CALL ADATA
      DO 9 M = 1,NEND
```

MAIN PROGRAM (METEOR)

```
    1 CALL UNOISE(AZ,120.0,180.0)
      IF(AZ.GT.360.0.OR.AZ.LT.0.0) GO TO 1
    2 CALL NOISE (EL,15.0,55.0)
      IF(EL.GT.80.0.OR.EL.LT.30.0) GO TO 2
      RAZ=AZ*RAD
      REL=EL*RAD
      EL3=SIN(RAZ)*COS(REL)
      EM3=COS(RAZ)*COS(REL)
      EN3=SIN(REL)
      IF(LINK(8).EQ.0) GO TO 3
      ZGT=104.0
      ZLT= 77.0
    3 CALL NOISE (Z,10.0,90.0)
      IF(Z.GT.ZGT.OR.Z.LT.ZLT) GO TO 3
      H=10.0*Z
C
C     CORRECT FOR EARTH'S CURVATURE, AND HEIGHT ABOVE SEA LE
     *VEL
C
      ZZ=Z-Z*Z*((1.0/(EN3*EN3))-1.0)/(2.0*EARTHR)-0.3
C
      RANGE=ZZ/EN3
      EL2=COSROT*EL3+SINROT*EM3
      EM2=COSROT*EM3-SINROT*EL3
      RR1=RANGE*RANGE+RACOR*RACOR
      RR2=RANGE*RCOR*EM2
      R=SQRT(RR1-RR2)
      EL1=(RANGE*EL2)/R
      EM1=(RANGE*EM2-RACOR)/R
      EL=EL1+ELCOR
      EM=EM1+EMCOR
C
      CALL  NOISE (TINC,1.0,2.5)
      T=T+TINC
      LTIMM=T+ITCOR
      LTIMS=60.0*(T+ITCOR-LTIMM)
      LTIMH=LTIMM/60
      JO=LTIMH/24
      LTIMM=LTIMM-LTIMH*60
      LTIMH=LTIMH-JO*24
      LTIMHM=LTIMH*100+LTIMM
      JO =JO + 1
      TIMH=LTIMH
      TIMM=LTIMM
      TIMH=TIMH+TIMM/60.0+ 0.5
```

MAIN PROGRAM (METEOR)

```
      IF(TIMH.LT.1.0)    TIMH = 24.5
      LT=TIMH
      CALL WIND
      VEL=U1*EL3 + V1*EM3 + W1*EN3
C
C     ADD 'NOISE' TO DRIFT VELOCITY
C
      MVEL=10.0*(VEL+0.5*VEL/ABS(VEL))
      IF(LINK(5).NE.0) CALL VNOISE (MVEL,RMSVEL,MVEL)
      VEL=MVEL
      VEL=VEL/10.0
C
      IF(ABS(VEL).LT.10.0) GO TO 1
      EL2M2=EL3*EL3+EM3*EM3
      E2L2M=1.0/EL2M2
      FL= (VEL*EL3*E2L2M)
      FM= (VEL*EM3*E2L2M)
      NFL=FL+0.5*FL/ABS(FL)
      NFM=FM+0.5*FM/ABS(FM)
      IF(M.EQ.NEND) UR=-1.0
      UR=UR+1.0
C
      IF(LINK(1).EQ.0) GO TO 6
C
C     SIMULATE ECHO AS TAPED AT GT METEOR WIND RECEIVING SIT
     *E
C
      WAVE=-WAVEL/VEL
      MWAVE1 = ABS(WAVE)
      ABWAVE = ABS (WAVE)
C
C     GENERATE SLIGHTLY DIFFERENT MEASURE OF VELOCITY (=WAVE
     *2)
C
      RMS = 0.1*ABWAVE
      CALL NOISE (WAVE2,RMS,WAVE)
      MWAVE2=ABS(WAVE2)
      IF(LINK(9).NE.0) MWAVE2=MWAVE1
C
C     ESTABLISH COUNTS APPROPRIATE TO PHASE AT EACH ANTENNA
C
      CALL ECHODF(MA,MB,MC,MD,EL ,EM ,WAVE)
C
C
C     ADD 'NOISE' TO PHASES
```

MAIN PROGRAM (METEOR)

```
C
      IF(LINK(6).EQ.0) GO TO 4
      RMS=RMSPH*ABWAVE
      CALL VNOISE (MA,RMS,MA)
      CALL VNOISE (MB,RMS,MB)
      CALL VNOISE (MC,RMS,MC)
      CALL VNOISE (MD,RMS,MD)
      MA=IABS(MA)
      MB=IABS(MB)
      MC=IABS(MC)
      MD=IABS(MD)
C
C     DIGITIZE RANGE 'PHASE', AND
C     GENERATE  SLIGHTLY DIFFERENT RANGE FOR RANGE2
C
    4 RFAC=ABWAVE/RLIM
      RR=SQRT(RR1+RR2)-RCOR
      MRNGE1=RFAC*(R+RR)
      IF(LINK(6).NE.0) CALL VNOISE (MRNGE1,RMS,MRNGE1)
      CALL NOISE (RANGE2,2.0,R)
      RFAC=ABS(WAVE2)/RLIM
      MRNGE2=RFAC*(RANGE2+RR)
      IF(LINK(10).NE.0) MRNGE2=MRNGE1
C
      MYRDAY=91+JO                                             @  APRIL YE
     *ARDAY
      MJOC=MYRDAY/100
      MJOD=(MYRDAY-MJOC*100)/10
      MJOU=MYRDAY-MJOC*100-MJOD*10
      MHRD=LTIMH/10
      MHRU=LTIMH-MHRD*10
      MIND=LTIMM/10
      MINU=LTIMM-MIND*10
      MSCD=LTIMS/10
      MSCU=LTIMS-MSCD*10
C
C     ENSURE THAT TIMING VARIABLES DO NOT CONTAIN '-0' COMPL
     *EMENT
C
      MJOU = IABS (MJOU)
      MJOD = IABS (MJOD)
      MJOC = IABS (MJOC)
      MHRU = IABS (MHRU)
      MHRD = IABS (MHRD)
      MINU = IABS (MINU)
```

MAIN PROGRAM (METEOR)

```
      MIND = IABS (MIND)
      MSCU=IABS(MSCU)
      MSCD=IABS(MSCD)
C
C
C     SIMULATE GT METEOR WIND DATA TAPE BLOCKED WORD RECORD
C
      DO5J=1,5
      DMZ(J)=0
      D(J)=0
      DMZ2(J)=0
    5 CONTINUE
C
      FLD(0,16,D(1))=MWAVE1
      FLD(16,16,D(1))=MA
      FLD(32,4,D(1))=FLD(20,4,MB)
      FLD(0,12,D(2))=FLD(24,12,MB)
      FLD(12,16,D(2))=MC
      FLD(28,8,D(2))=FLD(20,8,MD)
      FLD(0,8,D(3))=FLD(28,8,MD)
      FLD(8,16,D(3))=MRNGE1
      FLD(24,12,D(3))=FLD(20,12,MRNGE2)
      FLD(0,4,D(4))=FLD(32,4,MRNGE2)
      FLD(4,16,D(4))=MWAVE2
C
      FLD(20,4,D(4))=1
      FLD(24,4,D(4))=9
      FLD(28,4,D(4))=8
      FLD(32,4,D(4))=4
C
      FLD(0,4,D(5))=MJOC
      FLD(4,4,D(5))=MJOD
      FLD(8,4,D(5))=MJOU
      FLD(12,4,D(5))=MHRD
      FLD(16,4,D(5))=MHRU
      FLD(20,4,D(5))=MIND
      FLD(24,4,D(5))=MINU
      FLD(28,4,D(5))=MSCD
      FLD(32,4,D(5))=MSCU
C
C     FILE BINARY BLOCKED-WORD RECORD (FOR INPUT TO 'DECODE'
     *)
C
      CALL NTRAN (JTAPE,1,5,D,ISTAT,22)
      IF(ISTAT.NE.5) GO TO 10
```

```
      NFILE1=NFILE1+1
C
C     PRINT OUT OCTAL  WORDS FOR CHECKING PURPOSES
C
      IF(LINK(7).NE.0) WRITE(6,1013) D
 1013 FORMAT(1X,5020)
C
    6 IF(LINK(2).EQ.0) GO TO 7
C
C     LIST 'GROVES/ERG' TYPE INPUT
C
      WRITE(6,1014) UR,MY,MO,JO,LTIMHM,EL ,EM ,EL3,EM3,H,LEV
     *EL,LT,
     1NFL,NFM,VEL,MCS,MX,SOURCE,MWAVE1,MWAVE2,MA,MB,MC,MD,MR
     *NGE1,MRNGE2
 1014 FORMAT(F7.0,I2,2I3,I5,4F6.3, I4 ,I3,I2,2I4,F5.0,2I3,2A
     *4,
     12H *,8I6)
C
    7 IF(LINK(3).EQ.0) GO TO 8
C
C     FILE 'GROVES/ERG' INPUT (BINARY)
C
      LH=LTIMH
      LM=LTIMM
      WRITE(   4    )UR,MY,MO,JO,LH,LM ,EL ,EM ,EL3,EM3,Z,LEVE
     *L,LT,
     1NFL,NFM,VEL,MCS,MX,SOURCE
      NFILE2=NFILE2+1
C
    8 IF(LINK(4).EQ.0) GO TO 9
C
C     PUNCH BCD CARDS FOR 'LOADIT' ('GROVES/ERG' INPUT)
C
      PUNCH 1014,  UR,MY,MO,JO,LTIMHM,EL ,EM ,EL3,EM3,H,LEVE
     *L,LT,
     1NFL,NFM,VEL,MCS,MX,SOURCE
      NCARD=NCARD+1
C
    9 CONTINUE
      GO TO 11
   10 WRITE(6,1015)ISTAT
 1015 FORMAT(14H WRITE FOULUP.,3X,9H ISTAT = ,I6)
   11 END FILE 4
      DO12I=1,5
```

MAIN PROGRAM (METEOR)

```
      D(I)=EOF
   12 CONTINUE
      CALL NTRAN (JTAPE,1,5,D,ISTA!,22)
      WRITE(6,1016) NFILE1,FILE1,NFILE2,FILE2,NCARD
 1016 FORMAT(1H1/' OUTPUT FILE INVENTORY'/1X/1X,I6,48H RECOR
     *DS FOR INPUT
     1 TO 'DECODE', WRITTEN IN FILE ,2A6/1X/1X,I6,48H RECORD
     *S FOR INPUT
     2TO 'GROVES' OR 'ERG' IN FILE ,2A6/1X/1X,I6,36H CARDS P
     *UNCHED FOR I
     3NPUT TO 'LOADIT')
      REWIND  4
      CALL NTRAN (JTAPE,10)
      STOP
      END
```

```
      SUBROUTINE ADATA
C
C     DETERMINES MODEL WIND FIELD PARAMETERS FOR USE BY WIND
C     SIMULATES A 3,3,0 PROFILE NOT UNLIKE THE SEPTEMBER, 19
     *61 (ADELAIDE) DATA
C
      COMMON/CHUNK/ AC(70),NP,NQ,NR,NA0,NB0,NC0,NA(10),NB(10
     *),NC(10),
     1U1,V1,W1,T,Z,NANEW(10),ZMAX,ZMIN
C
      T=0.0
      ZMIN=76.0
      ZMAX=106.0
      NP=3
      NQ=3
      NR=3
      NA0=3
      NB0=3
      NC0=0
      DO1J=1,3
      NA(J)=3
      NB(J)=3
      NC(J)=0
    1 CONTINUE
      AC(1)=12.0
      AC(2)=-31.9
      AC(3)=-74.5
      AC(4)=26.1
      AC(5)=5.8
      AC(6)=141.8
      AC(7)=14.0
      AC(8)=-211.2
      AC(9)=-2.7
      AC(10)=11.1
      AC(11)=-45.7
      AC(12)=-84.9
      AC(13)=17.2
      AC(14)=-62.5
      AC(15)=-29.6
      AC(16)=143.9
      AC(17)=-29.5
      AC(18)=-38.6
      AC(19)=39.5
      AC(20)=77.0
      AC(21)=-19.5
      AC(22)=63.4
```

```
SUBROUTINE ADATA



AC(23)=79.8
AC(24)=-131.0
AC(25)=-4.1
AC(26)=18.4
AC(27)=-30.3
AC(28)=6.2
AC(29)=10.7
AC(30)=33.6
AC(31)=25.8
AC(32)=-5.9
AC(33)=-20.0
AC(34) = 0.0
AC(35)=-34.2
AC(36)=-38.3
AC(37)=1.3
AC(38)=24.2
AC(39)=7.6
AC(40)=-37.1
AC(41)=-0.5
AC(42)=7.9
AC(43)=16.6
AC(44)=-4.3
AC(45)=-23.9
AC(46)=-48.4
AC(47)=95.2
AC(48)=70.8
AC(49)=1.6
AC(50)=14.9
AC(51)=-16.4
AC(52)=-57.8
AC(53)=10.0
AC(54)=-11.0
AC(55)=-52.0
AC(56)=31.3
AC(57)=-6.5
AC(58)=-3.5
AC(59)=-2.5
AC(60)=-1.2
AC(61)=-3.0
AC(62)=-0.6
AC(63)=1.0
RETURN
END
```

```
      SUBROUTINE NOISE (F,RMS,AVGE)
C
C      A GENERAL NOISE GENERATING ROUTINE, WITH TWO ENTRY POI
     *NTS.
C
C      NOISE, WHICH GERERATES, ON EACH CALL, ONE OF A NORMALL
     *Y DISTRIBUTED
C      (GAUSSIAN) SET OF NUMBERS WITH AVERAGE AVGE, AND STAND
     *ARD
C      DEVIATION EQUAL TO RMS.
C
C      UNOISE, WHICH  GENERATES, ON EACH CALL, ONE OF A UNIFO
     *RMLY
C      DISTRIBUTED (RECTANGULAR) SET OF NUMBERS, ALSO WITH AV
     *ERAGE AVGE,
C      AND STANDARD DEVIATION EQUAL TO RMS.
C
C      PROGRAM REQUIRES COMMON/COUNTR/N IN MAIN (CALLING) PRO
     *GRAM, WITH
C      N SET TO ZERO PRIOR TO FIRST (ONLY) CALL TO THIS SUBRO
     *UTINE
C
      COMMON/COUNTR/N
      TOTAL=0.0
      I=1
      SCALE=10.605229
      DIV=8.0
      GOTO 100
C
      ENTRY UNOISE (F,RMS,AVGE)
      TOTAL=0.0
      I=8
      SCALE= 3.46035
      DIV=1.0
C
  100 N=N+1
      IF(N-1)1,1,2
C
C      SET UP RANDOM NUMBER GENERATOR, TO GENERATE A SERIES
C                X(N+1) = X(N) * T  (MOD MAX)
C      WHERE    X(1) = 1
C               T = 509
C               MAX = 262144
C
    1 IX=1
      IT=509
```

```
      SUBROUTINE NOISE (F,RMS,AVGE)


      IMAX=262144
      FMAX=IMAX
C
    2 IX=IT*IX
      MULT=IX/IMAX
      FX=IX-MULT*IMAX
      IX=FX
C
C     NORMALIZE, SO THAT THE NUMBER LIES IN THE INTERVAL  0,
     *1
C
      U=FX/FMAX
C
C     IF A NORMAL SET IS REQUIRED, AVERAGE EIGHT NUMBERS OF
     *THE
C     UNIFORM SET, TO PRODUCE ONE NUMBER OF THE NORMAL SET.
C
      TOTAL=TOTAL+U/DIV
      IF(I-8)3,4,4
    3 I=I+1
      GOTO2
C
C      SET MEAN VALUE TO ZERO.
C
    4 F=TOTAL-0.5
C
C     SCALE TO MEAN AVERAGE, STANDARD DEVIATION RMS.
C
      F=F*SCALE*RMS+AVGE
      RETURN
      END
```

```
      SUBROUTINE VNOISE (NF,RMS,NAVGE)
C
C     A REPEAT OF 'NOISE' WHICH PROCESSES INTEGERS.
C
      COMMON/VCOUNT/NV
C
      AVGE=NAVGE
      TOTAL=0.0
      I=1
      NV=NV+1
      IF(NV-1)1,1,2
    1 IX=1
      IT=509
      IMAX=262144
      FMAX=IMAX
      SCALE=10.605229
      DIV=8.0
    2 IX=IT*IX
      MULT=IX/IMAX
      FX=IX-MULT*IMAX
      IX=FX
      U=FX/FMAX
      TOTAL=TOTAL+U/DIV
      IF(I-8)3,4,4
    3 I=I+1
      GOTO2
    4 E=TOTAL-0.5
      NF=E*SCALE*RMS+AVGE
      RETURN
      END
```

```
      SUBROUTINE WIND
C     GENERATES WIND COMPONENTS U1, V1, AND W1 FOR USE BY 'M
     *ETEOR'
C
      DIMENSION SI(3),CO(3)
      COMMON/CHUNK/ AC(70),NP,NQ,NR,NA0,NB0,NC0,NA(10),NB(10
     *),NC(10),
     1U1,V1,W1,T,Z,NANEW(10),ZMAX,ZMIN
C
      TH=T/60.0
      DO1J=1,3
      FJ=J
      THJ=TH*FJ*0.2618
      SI(J)=SIN(THJ)
      CO(J)=COS(THJ)
    1 CONTINUE
      DO2J=1,NP
      NANEW(J)=NA(J)
    2 CONTINUE
      NPNEW=NP
      KEND=0
      NA0E=NA0+1
      NB0E=NB0+1
      NC0E=NC0+1
      NSIGN=-1
    3 KA=KEND
      U0=0.0
      U=0.0
      S=(2.0*Z-ZMAX-ZMIN)/(ZMAX-ZMIN)+ 1.0E-06
      DO4K=1,NA0E
      KUA=K+KA
      U0 = U0+AC(KUA)*S**(K-1)
    4 CONTINUE
      IF(NPNEW.LE.0) GO TO 7
      KEND=KA+NA0E
      DO5J=1,NPNEW
      KSTART=KEND
      NAEND=NANEW(J)+1
      KEND=KSTART+NAEND
      DO5K=1,NAEND
      KU=K+KSTART
      U=U+AC(KU)*S**(K-1)*SI(J)
    5 CONTINUE
      DO6J=1,NPNEW
      KSTART=KEND
      NAEND=NANEW(J)+1
```

SUBROUTINE WIND

```
      KEND=KSTART+NAEND
      DO6K=1,NAEND
      KU=K+KSTART
      U=U+AC(KU)*S**(K-1)*CO(J)
    6 CONTINUE
      U=U+U0
      IF(ABS(U).LT.999.0) GO TO 8
      U=SIGN(999.0,U)
      GO TO 8
    7 KEND=KA+NA0E
      U=U0
      IF(ABS(U).LT.999.0) GO TO 8
      U=SIGN(999.0,U)
    8 IF(NSIGN)9,11,13
    9 U1=U
      NA0E=NB0E
      NPNEW=NQ
      DO10J=1,NQ
      NANEW(J)=NB(J)
   10 CONTINUE
      NSIGN=0
      GO TO 3
   11 V1=U
      NA0E=NC0E
      NPNEW=NR
      DO12J=1,NR
      NANEW(J)=NC(J)
   12 CONTINUE
      NSIGN=1
      GO TO 3
   13 W1=U
      RETURN
      END
```

```
      SUBROUTINE ECHODF (MA,MB,MC,MD,EL,EM,WAVE)
C
C     SIMULATES DIRECTION FINDING RECEIVER DIGITAL OUTPUTS.
C
      MWAVE=ABS(WAVE)
      MA=-WAVE*EL
      MB=-WAVE*EM
      MC=WAVE*(1.25*EM+0.25)
      MD=WAVE*(1.75*EM-0.5*EL+0.75)
      CALL NORMAL (MA,MWAVE)
      CALL NORMAL (MB,MWAVE)
      CALL NORMAL (MC,MWAVE)
      CALL NORMAL (MD,MWAVE)
      RETURN
      END
```

```
      SUBROUTINE NORMAL (MW,MWAVE)
C
C     NORMALIZES MW ON THE INTERVAL 0,MWAVE
C
    1 IF(MW.LT.MWAVE) GO TO 2
      MW=MW-MWAVE
      GO TO 1
    2 IF(MW.GT.0) RETURN
      MW=MW+MWAVE
      GO TO 2
      END
```

MAIN PROGRAM (DECODE)

```
C      PROGRAM DECODE        GEORGIA TECH RADIO METEOR WIND FAC
      *ILITY  026 PUNCH
C      METEOR ECHO DATA TAPE PROCESSOR  ( SINGLE SITE )
C
C      ADAPTATION OF UNIVERSITY OF ADELAIDE PHYSICS DEPARTMEN
      *T PROGRAM 1190A
C      WRITTEN IN FORTRAN V FOR GEORGIA TECH UNIVAC 1108.
C      READS GT METEOR WIND DATA TAPE, AND LOADS FASTRAND FIL
      *E
C
C      DECK IS LOADED AS FOLLOWS -
C      MAIN PROGRAM
C      SUBROUTINES SITE
C                  READER
C                  SOLVE
C                  MONDAY
C                  PAGE
C     @XQT
C      YEAR DATA TAPE WAS RECORDED         FORMAT 1X,I4
C      HEADER/SOURCE CARD                  FORMAT 12A6,2A4
C      INPUT FILE NAME                     FORMAT 2A6
C      OUTPUT FILE NAME                    FORMAT 2A6
C      DATA CONTROL OPTIONS CARD, PUNCHED AS FOLLOWS -
C       COL   PUNCH                   OPTION
C        1      1     SUPPRESS ZENITH ANGLE REJECTION
C        2      1     SUPPRESS HEIGHT REJECTION
C        3      1     SUPPRESS DOPPLER COMPARISON
C        4      1     SUPPRESS RANGE REJECTION (LESS THAN 65K
      *M)
C        5      1     SUPPRESS RANGE COMPARISON
C        6      1     SUPPRESS PRINTOUT OF UNACCEPTABLE ECHOE
      *S
C        7      1     SUPPRESS TAPE READ DIAGNOSTICS
C      NEXT 3 COLUMNS LEFT BLANK (USE FOR FUTURE OPTIONS)
C      START NUMBER, ERROR LIMITS,
C      SYSTEM LOGIC DELAY FACTORS,
C      AND ERROR COUNT START.              FORMAT 10I1,F10.0,2F
      *5.2,5I10
C      CLOCK RATE FOR SCALING DATA.        FORMAT F7.0
C      EOF
C
C      UNIT 16 IS FASTRAND OUTPUT FILE
C      UNIT 17 IS DATA TAPE INPUT FILE
C
       REAL NSSHFT
```

MAIN PROGRAM (DECODE)

```
      INTEGER H,FLAG,DOL
      DIMENSION LINK(10),FILEIN(2),FILOUT(2),FINIS(29),MLIST
     *(8)
      COMMON UR,MY,MO,JO,LH,LM,RANGE,WAVE,MON
      COMMON/YEAR/NYEAR
      COMMON /TRSYS/ RCOR,COSROT,SINROT,ELCOR,EMCOR,ITCOR,
     1NSSHFT,EWSHFT,EARTHR
      COMMON/HSKP/HEADER(12),SOURCE(2),NOP,LINE,LINES,ITAPE
      COMMON /ERROR/ MISS,NBIT,NBITE,IPAR,LINK,NBAD
      COMMON /CONST/ RMAX,EOF,ICAL
      COMMON /IOLIST/ MWAVE1,MWAVE2,MA,MB,MC,MD,MRNGE1,MRNGE
     *2,MSEC
      EQUIVALENCE (MLIST,MWAVE1)
C
C     CONSTANTS
C
      ICAL=5H*****
      DOL=1H$
      EOF=6HEOFEOF
      RMAX=208.182
      ITAPE=17
C
C     INITIALIZE
C
      REWIND 16
      CALL NTRAN (ITAPE,10)
      ASSIGN 105 TO NHITE
      NBAD=-2
      IPAR=0
      MISS=0
      NBITE=-2
      LINE=-1
      NOP=0
      NREC=0
      METEOR=0
C
C     READ YEAR ECHO DATA TAPE WAS RECORDED
C
      READ(5,999) NYEAR,MOVE
  999 FORMAT(1X,I4,I5)
      WRITE(6,999) NYEAR,MOVE
      IF(MOVE.NE.0) CALL NTRAN (ITAPE,8,MOVE,22)
C
      READ(5,1000) HEADER,SOURCE
 1000 FORMAT(12A6,2A4)
```

MAIN PROGRAM (DECODE)

```
      CALL PAGE
C
C     NAME INPUT FILE (FILEIN), AND OUTPUT FILE (FILOUT)
C
      READ(5,1000) FILEIN
      READ(5,1000) FILOUT
      WRITE(6,1001) FILEIN,FILOUT
 1001 FORMAT(16H INPUT  FILE IS ,2A6,2X,16H OUTPUT FILE IS ,
     *2A6)
C
C     WRITE FASTRAND FILE (FILEOUT) LABEL
C
      WRITE(16,1000) HEADER,SOURCE
C
C     READ OPTIONS CARD
C
      READ(5,1002) LINK,UR,ERORX,ERORC,LA,LB,LC,LD,NBIT
 1002 FORMAT(10I1,F10.0,2F5.2,5I10)
      URSTRT=UR
      NBITO=NBIT
      IF(LINK(2).NE.0) ASSIGN 35 TO NHITE
      WRITE(6,1020) LINK,UR,ERORX,ERORC,LA,LB,LC,LD,NBIT
 1020 FORMAT(7H LINK  ,10I1/13H START NUMBER,F8.0/22H PHASES
     * MATCHED TO
     1X =,F5.2,5H, C =,F5.2/25H DIGITAL LOGIC PHASE LAGS,4I1
     *0/5H NBIT,I5
     2)
C
C     COUNT FACTOR FOR SCALING DATA
C
      READ(5,1003) CLOCK
      SCALE=(30.0/32.5)*5.0*CLOCK
      WRITE(6,1003) SCALE
C
C     OBTAIN TRANSMIT/RECEIVE SYSTEM SITE CONSTANTS
C
      CALL SITE
      F=RCOR/2.0
C
      LINE=0
      LINES=4
      CALL PAGE
      LINE=10
C
C     CALL TAPE READ SUBROUTINE
```

MAIN PROGRAM (DECODE)

```
C
    1 CALL READER
      IF(MISS.GT.0) GO TO 200
      LOOP=0
C
C     DOPPLER SPEED
C
      VEL=SCALE/WAVE
C
C     LOCAL MEAN SOLAR TIME OF ECHO
C
      LHLM = 100*LH+LM
C
C     DETERMINE DIRECTION COSINES OF ECHO ARRIVAL ANGLE
C
      MB=MB+LA-LB
      MC=MC+LA-LC
      MD=MD+LA-LD
      AL=MA/WAVE
      BL=MB/WAVE
      CL=MC/WAVE
      DL=MD/WAVE
    2 IF(AL.LT.1.0) GO TO 3
      AL=AL-1.0
      GO TO 2
    3 IF(BL.LT.1.0) GO TO 4
      BL=BL-1.0
      GO TO 3
    4 IF(CL.LT.1.0) GO TO 5
      CL=CL-1.0
      GO TO 4
    5 IF(DL.LT.1.0) GO TO 6
      DL=DL-1.0
      GO TO 5
    6 VEL=-VEL
      MVEL=VEL
      LOOP=LOOP+1
      IF(CL.LT.DL) GO TO 7
      XL=CL-DL
      GO TO 8
    7 XL=1.0+CL-DL
    8 EL=-AL
      EM = -BL
      XLC = (EL/2.0)-(EM/2.0)+0.5
      CALL SOLVE(XL,XLC,ERORX,MXZ,MX)
```

MAIN PROGRAM (DECODE)

```
      NSTAT=1
    * NSTAT = 1
      IF(MXZ)9,100,10
    9 EL=1.0-AL
      XLC=(EL/2.0)-(EM/2.0)+0.5
      CALL SOLVE(XL,XLC,ERORX,MXZ,MX)
      NSTAT=2
    * NSTAT = 2
      IF(MXZ)107,100,18
   10 IF(MVEL)11,100,12
   11 EL=AL
      EM=BL
      CLC=0.75-(1.25*EM)
      GO TO 13
   12 CLC=(1.25*EM)+0.25
   13 CALL SOLVE(CL,CLC,ERORC,MCZ,MCS)
      NSTAT=3
    * NSTAT = 3
      IF(MCZ)14,100,26
   14 IF(MVEL)15,100,16
   15 EL=AL-1.0
      EM=BL-1.0
      CLC=0.75-(1.25*EM)
      GO TO 17
   16 EL=1.0-AL
      EM=1.0-BL
      CLC=(1.25*EM)+0.25
   17 CALL SOLVE(CL,CLC,ERORC,MCZ,MCS)
      NSTAT=4
    * NSTAT = 4
      IF(MCZ)107,100,26
   18 IF(MVEL)19,100,20
   19 EL=AL-1.0
      EM=BL
      CLC=0.75-(1.25*EM)
      GO TO 21
   20 EL=1.0-AL
      EM=-BL
      CLC=(1.25*EM)+0.25
   21 CALL SOLVE(CL,CLC,ERORC,MCZ,MCS)
      NSTAT=5
    * NSTAT = 5
      IF(MCZ)22,100,26
   22 IF(MVEL)23,100,24
   23 EL=AL
```

MAIN PROGRAM (DECODE)

```
      EM=BL-1.0
      CLC=0.75-(1.25*EM)
      GO TO 25
   24 EL=-AL
      EM=1.0-BL
      CLC=(1.25*EM)+0.25
   25 CALL SOLVE(CL,CLC,ERORC,MCZ,MCS)
      NSTAT=6
     * NSTAT = 6
      IF(MCZ)107,100,26
C
C     APPLY SITE CORRECTIONS TO DIRECTION COSINES
C
   26 EL1=EL+ELCOR
      EM1=EM+EMCOR
      IF(LINK(1).NE.0) GO TO 27
      ZENITH=(EL1*EL1)+(EM1*EM1)
      NSTAT=8
     * NSTAT = 8
      IF(ZENITH.GT.0.95) GO TO 104
C
C     CALCULATE COORDS OF ECHO CENTER ON REFLECTION ELLIPSE
     *(MIDPOINT ORIGIN)
C
   27 SINEM1=SQRT(1.0-EM1*EM1)
      A=RANGE
      A2=A**2
      B=A**2-F**2
      S=(A-EM1*F)/((EM1*EM1)+((A2/B)*SINEM1*SINEM1))
      X=F+EM1*S
      Y=S*SINEM1
C
C     DISTANCE FROM MIDPOINT TO X INTERCEPT OF TRAIL NORMAL
     *(KILOMETERS)
C
      XO=X*F*F/(4.0*A2)
C
C     TRUE LINE OF SITE RANGE            (KILOMETERS)
C
      XACT=X-XO
      RANGEX=SQRT(XACT*XACT+Y*Y)
C
C     TRANSLATION FACTORS                (KILOMETERS)
C
      XO=F-XO
```

MAIN PROGRAM (DECODE)

```
C
C     TRANSLATE AXES TO LINE OF SIGHT ORIGIN
C
      EL2=EL1*S/RANGEX
      EM2=(EM1*S+XO)/RANGEX
C
C     ROTATE TO NORTH-SOUTH, EAST-WEST AXES
C
      EL3=COSROT*EL2+SINROT*EM2
      EM3=COSROT*EM2-SINROT*EL2
      EN32=1.0-EL3*EL3-EM3*EM3
      IF(LINK(1).EQ.0.AND.EN32.LT.0.001) GO TO 104
      EN3=SQRT(EN32)
C
C     CALCULATE ECHO HEIGHT, INCLUDING EARTH CURVATURE CORRE
     *CTION
C     AND CORRECTION FOR HEIGHT ABOVE SEA LEVEL
C
      HITE=RANGEX*EN3+RANGEX*RANGEX*(1.0-EN3*EN3)/(2.0*EARTH
     *R)+0.3
      H=10.0*HITE
C
C     CALCULATE LOCAL MEAN SOLAR TIME, LT, TO THE NEAREST HO
     *UR
C
      IF(LM-30)28,29,29
   28 LT=LH
      GO TO 30
   29 LT=LH+1
   30 NSTAT=9                                                   @
     * NSTAT = 9
      IF(LT)100,31,32
   31 LT=24
C
C     DETERMINE APPROPRIATE LEVEL (10 KM HEIGHT BLOCK)
C
   32 KHT=HITE+0.5
      LEVEL=6
      NSTAT=10                                                  @
     * NSTAT = 10
      IF(KHT.LT.70) GO TO NHITE
      IF(KHT.GT.85) GO TO 33
      LEVEL=1
      GO TO 35
   33 IF(KHT.GT.95) GO TO 34
```

```
      LEVEL=2
      GO TO 35
   34 IF(KHT.GT.120) GO TO NHITE
      LEVEL=3
      IF(KHT.GT.105) LEVEL = 4
C
C     CALCULATE QUICK LOOK TYPE WIND VELOCITY COMPONENTS
C
   35 EL2M2=EL3*EL3+EM3*EM3
      E2L2M=1.0/EL2M2
      FL=-(VEL*EL3*E2L2M)
      FM=-(VEL*EM3*E2L2M)
      NFL=FL+0.5*FL/ABS(FL)
      NFM=FM+0.5*FM/ABS(FM)
C
C     ATTATCH TRUE SIGN TO LINE OF SIGHT VELOCITY VECTOR
C
      VEL=-VEL
C
C     OUTPUT - ONE RECORD PER ACCEPTABLE ECHO
C
      WRITE(16) UR,MY,MO,JO,LH,LM,EL ,EM ,EL3,EM3,HITE,LEVEL
     *,LT,
     1NFL,NFM,VEL,MCS,MX,SOURCE,MLIST,MSEC
      NREC=NREC+1
      FLAG=DOL
      IF(H.LT.760.OR.H.GT.1060) FLAG = 1H
      IF(FLAG.EQ.DOL) METEOR=METEOR+1
C
C     LIST ACCEPTABLE ECHO DATA
C
      WRITE(6,1003) UR,MY,MO,JO,LHLM,EL,EM,EL3,EM3,H    ,LEVE
     *L,LT,
     1NFL,NFM,VEL,MCS,MX,SOURCE,FLAG,MLIST,MSEC
 1003 FORMAT(F7.0,I2,2I3,I5,4F6.3,I5,I3,I2,2I4,F5.0,2I3,2A4,
     *1X,A1,9I5)
      CALL PAGE
      NBITE=NBITE-1
      GO TO 1
C
C     TABLE OF DIAGNOSTIC MESSAGES
C
  100 WRITE(6,1004) UR,NSTAT,LH,LM,MON,JO
 1004 FORMAT(40X,F7.0,16HFAULT FOR NSTAT=I3,8H, TIME =I3,4H
     *HRS,
```

```
     1I3,5H MINS,3X,A3,I3)
      GO TO 106
  101 WRITE(6,1005) UR,LH,LM,MON,JO,RANGE,MLIST,MSEC
 1005 FORMAT(F7.0,16H NO CHECK FOR X,,6X,8H TIME = ,I3,4H HR
     *S,
     1I3,5H MINS,3X,A3,I3,6H RANGE,F8.1,8X,9I5)
      GO TO 106
  102 WRITE(6,1006) UR,LH,LM,MON,JO,RANGE,MLIST,MSEC
 1006 FORMAT(F7.0,21H NO CHECK FOR C,L1,M1,9H, TIME = ,I3,4H
     * HRS,
     1I3,5H MINS,3X,A3,I3,6H RANGE,F8.1,8X,9I5)
      GO TO 106
  103 WRITE(6,1007) UR,LH,LM,MON,JO,RANGE,MLIST,MSEC
 1007 FORMAT(F7.0,21H NO CHECK FOR C,L2,M2,9H, TIME = ,I3,4H
     * HRS,
     1I3,5H MINS,3X,A3,I3,6H RANGE,F8.1,8X,9I5)
      GO TO 106
  104 IF(LINK(6).NE.0) GO TO 108
      WRITE(6,1008) UR,LH,LM,MON,JO,RANGE,MLIST,MSEC
 1008 FORMAT(F7.0,21H L2+M2 EXCEEDS 0.95, ,9H  TIME = ,I3,4H
     * HRS,
     1I3,5H MINS,3X,A3,I3,6H RANGE,F8.1,8X,9I5)
      GO TO 106
  105 IF(LINK(6).NE.0) GO TO 108
      WRITE(6,1009) UR,KHT,LH,LM,MON,JO,RANGE,MLIST,MSEC
 1009 FORMAT(F7.0,16H HEIGHT QUERY,  ,I5,9H, TIME = ,I3,4H H
     *RS,
     1I3,5H MINS,3X,A3,I3,6H RANGE,F8.1,8X,9I5)
  106 CALL PAGE
      GO TO 1
C
C     IF REJECTED ON THE FIRST PASS, LOOP AGAIN WITH SIGN OF
     * VELOCITY CHANGED.
C
  107 IF(LOOP.EQ.1) GO TO 6
      IF(LINK(6).NE.0) GO TO 108
      NLOOP=NSTAT/2
      GO TO (101,102,103,104,105),NLOOP
  108 NBITE=NBITE+1
      GO TO 1
C
C     WRITE LAST  FILOUT RECORD AS ALL ZEROES
C
  200 DO201I=1,29
      FINIS(I)=0.0
```

```
  201 CONTINUE
      WRITE(16) FINIS
      END FILE 16
C
C     WRITE OUT FILE STATISTICS
C
      NECHO=UR-URSTRT-MISS/2
      NBIT=NBIT-NBITO
      IF(LINE.EQ.0) GO TO 202
      LINE=50
      CALL PAGE
      NBITE=NBITE-1
  202 WRITE(6,1010) NECHO,FILEIN,NBIT,NREC,FILOUT,NBITE,NBAD
     *,MISS
 1010 FORMAT(1X,28HINPUT/OUTPUT FILE STATISTICS/1X
     1       /1X,I6,28H ECHOES READ FROM INPUT TAPE,1X,2A6,
     2/1X/1X,I6,28H OF THESE BEING INCONSISTENT   /1X/1X,I6,
     *26H RECORDS
     3IN FASTRAND FILE ,2A6/1X/1X,I6,8H REJECTS/1X/1X,I6,12H
     * TAPE CHECKS
     4/1X/100X,4HMISS,I3/1X)
C
C     LIST NON-STANDARD OPTIONS USED
C
      IF(LINK(1).NE.0) WRITE(6,1011)
 1011 FORMAT(1X/42H 1.       NO ZENITH ANGLE CRITERION IMPOSE
     *D/1X)
      IF(LINK(2).NE.0) WRITE(6,1012)
 1012 FORMAT(1X/46H 2.       NO RESTRICTIONS ON ACCEPTABLE HE
     *IGHTS/1X)
      IF(LINK(3).NE.0) WRITE(6,1013)
 1013 FORMAT(1X/30H 3.       NO DOPPLER COMPARISON/1X)
      IF(LINK(4).NE.0) WRITE(6,1014)
 1014 FORMAT(1X/28H 4.       ALL RANGES ACCEPTED/1X)
      IF(LINK(5).NE.0) WRITE(6,1015)
 1015 FORMAT(1X/28H 5.       NO RANGE COMPARISON/1X)
      IF(LINK(6).NE.0) WRITE(6,1016)
 1016 FORMAT(1X/27H 6.       REJECTS NOT LISTED/1X)
      IF(LINK(7).NE.0) WRITE(6,1017)
 1017 FORMAT(1X/37H 7.       TAPE DIAGNOSTICS NOT PRINTED/1X)
C
C     LIST NUMBER OF USEABLE METEOR ECHOES.
C
      WRITE(6,1018) METEOR
 1018 FORMAT(/////1X,I6,28H USEABLE METEOR ECHOES FILED/1H1)
```

MAIN PROGRAM (DECODE)

```
C
      REWIND 16
      CALL NTRAN (ITAPE,10)
      STOP
      END
```

```
      SUBROUTINE SITE
C     TABULATION OF SITE CONSTANTS FOR USE BY 'DECODE'
C
C     NOTE - WEST LONGITUDES AND SOUTHERN LATITUDES ARE NEGA
     *TIVE
C     SIGN IS ATTATCHED TO DEGREES ONLY, NOT TO MINUTES AND
     *SECONDS.
C
      COMMON /TRSYS/ RCOR,COSROT,SINROT,ELCOR,EMCOR,ITCOR,
     1NSSHFT,EWSHFT,EARTHR
C
      REAL NSSHFT
C
C     TRANSMITTER LAT/LON
C
      TLATD=33.0
      TLATM=46.0
      TLATS=19.0
      TLOND=-84.0
      TLONM=23.0
      TLONS=46.0
C
C     RECEIVING SITE LAT/LON
C
      RLATD=33.0
      RLATM=57.0
      RLATS=56.0
      RLOND=-84.0
      RLONM=13.0
      RLONS=07.0
C
C     EARTH'S RADIUS       (KILOMETERS)
C
      EARTHR=6371.9
C
C     TRANSMITTER/RECEIVER SITE SEPARATION       (KILOMETERS)
C
      RCOR=27.037
C
C     MIDPOINT TRANSLATION FACTORS               (KILOMETERS)
C
      EWSHFT=-8.203
      NSSHFT=-10.745
C
C     ROTATION FACTORS, SYSTEM AXES TO NORTH - SOUTH, EAST -
     * WEST
```

```
      SUBROUTINE SITE


C
      COSROT=0.7949
      SINROT=0.6068
C
C     DF DIRECTION COSINE CORRECTIONS
C
      ELCOR=0.0
      EMCOR=0.0
C
C     LOCAL MEAN SOLAR TIME CORRECTION    (MINUTES)
C
      ITCOR=-37
C
C     LIST TRANSMIT/RECEIVE SITE PARAMETERS
C
      WRITE(6,1000) TLATD,TLATM,TLATS,TLOND,TLONM,TLONS,RLAT
     *D,RLATM,RLAT
     1S,RLOND,RLONM,RLONS,RCOR,EWSHFT,NSSHFT,ELCOR,EMCOR,COS
     *ROT,SINROT,
     2ITCOR
 1000 FORMAT(/1X,'TRANSMITTER LATITUDE', 3F4.0,' LONGITUDE',
     * 3F4.0/
     1' RECEIVER    LATITUDE' , 3F4.0,' LONGITUDE',3F4.0/' T
     */R SEPARATIO
     2N',F8.3,'KM'/' MIDPOINT COORDINATES',2F8.3/' RECEIVING
     * SITE ANTENN
     3A CORRECTIONS, L',F8.4,' M',F8.4/' AXIS ROTATION COS',
     *F8.4,'  SIN'
     4,F8.4/' LOCAL MEAN SOLAR TIME CORRECTION',I4,' MINUTES
     *.')
C
      RETURN
      END
```

```
      SUBROUTINE READER
C
C     READS GT METEOR WIND DATA TAPE, AND UNBLOCKS.
C
      DIMENSION MLIST(8)
      INTEGER DMZ(5),D(5),DMZ2(5),EOF
C
      COMMON UR,MY,MO,JO,LH,LM,RANGE,WAVE,MON
      COMMON /BUFFER/ DMZ,D,DMZ2
      COMMON/YEAR/NYEAR
      COMMON/TRSYS/RCOR,ROTL,ROTM,ELCOR,EMCOR,ITCOR
      COMMON/HSKP/HEADER(12),SOURCE(2),NOP,LINE,LINES,ITAPE
      COMMON/ERROR/MISS,NBIT,NBITE,IPAR,LINK(10),NBAD
      COMMON /CONST/ RMAX,EOF,ICAL
      COMMON /IOLIST/ MWAVE1,MWAVE2,MA,MB,MC,MD,MRNGE1,MRNGE
     *2,MSEC
      EQUIVALENCE (MLIST,MWAVE1)
C
C     INITIALIZE
C
      JSTOP=0
      JMY=0
      JPAR=0
C
    1 UR=UR+1.0
C
      DO2I=1,5
      D(I)=0
    2 CONTINUE
C
C     DISABLE FORTRAN I/O, AND READ 5 WORD RECORD FROM ECHO
     *DATA TAPE.
C
      CALL NTRAN (ITAPE,2,5,D,ISTAT,22)
C
C     CHECK READ STATUS
C
      IF(ISTAT.NE.5) NBAD=NBAD+1
      IF(ISTAT.EQ.-3) JPAR=JPAR+1
      IF(ISTAT.NE.-2) JSTOP=0
      IF(ISTAT.EQ.-2) JSTOP=JSTOP+1
      IF(JSTOP.EQ.1) GO TO 1
      IF(ISTAT.NE.5) GO TO 4
C
C     CHECK FOR FLAG RECORD (IN CASE SIMULATED DATA GENERATE
     *D BY 'METEOR'
```

```
      SUBROUTINE READER

C     IS BEING READ).
C
      DO3I=1,5
      IF(D(I).NE.EOF) GO TO 5
    3 CONTINUE
      GO TO 11
    4 IF(ISTAT.EQ.-2.OR.ISTAT.EQ.-4) GO TO 11
C
C     UNPACK DATA WORDS
C
    5 MSIGN=FLD(0,1,D(1))
      MWAVE1=FLD(1,15,D(1))
      MA=FLD(16,16,D(1))
      MB=FLD(0,12,D(2))
      FLD(20,4,MB)=FLD(32,4,D(1))
      MC=FLD(12,16,D(2))
      MD=FLD(0,8,D(3))
      FLD(20,8,MD)=FLD(28,8,D(2))
      MRNGE1=FLD(8,16,D(3))
      MRNGE2=FLD(0,4,D(4))
      FLD(20,12,MRNGE2)=FLD(24,12,D(3))
      MWAVE2=FLD(5,15,D(4))
C
      WAVE1=MWAVE1
      WAVE2=MWAVE2
C
C
C     CHECK CONSISTENCY OF DOPPLER WAVELENGTH
C
      IF(WAVE1.LT.500) WAVE1=WAVE2
      IF(WAVE1.LT.500.0.AND.LINK(6).EQ.0) WRITE(6,1000) UR,M
     *LIST
 1000 FORMAT(F7.0,31H DOPPLER FREQUENCY INCONSISTENT,45X,8I5
     *)
      IF(WAVE1.LT.500.0) GO TO 9
      WDIFF=ABS((WAVE1-WAVE2)/WAVE1)
      IF(WDIFF.LT.0.2.OR.LINK(3).NE.0) GO TO 6
      IF(LINK(6).EQ.0) WRITE(6,1000) UR,MLIST
      GO TO 9
C
    6 WAVE=WAVE1
      IF(WAVE2.LT.100.0) WAVE2=WAVE1
C
C     CHECK CONSISTENCY OF RANGE COUNT
C
```

SUBROUTINE READER

```
      IF(MRNGE1.LT.100.AND.MRNGE2.GT.MRNGE1) MRNGE1=MRNGE2
      IF(MRNGE1.GT. WAVE1) MRNGE1=MRNGE1- WAVE1
      IF(MRNGE2.GT. WAVE2) MRNGE2=MRNGE2- WAVE2
C
C     CHECK CONSISTENCY OF RANGE        (APPROX.    TO NEAREST
     * KILOMETER)
C
      RANGE1= RMAX*MRNGE1/ABS(WAVE1)+RCOR/2.0
      RANGE2= RMAX*MRNGE2/ABS(WAVE2)+RCOR/2.0
      RDIFF=ABS(RANGE1-RANGE2)
      IF(RANGE1.LT.65.0.AND.LINK(4).EQ.0) GO TO 69
      IF(RDIFF.LT.4.0.OR.LINK(5).NE.0) GO TO 7
   69 IF(LINK(6).EQ.0) WRITE(6,1001) UR,RANGE1,RANGE2,MLIST
 1001 FORMAT(F7.0,19H RANGE INCONSISTENT,2F8.1,41X,8I5)
      GO TO 9
    7 RANGE=RANGE1
      F=(RCOR/2.)+0.5
      IF(RANGE.LT.F) RANGE=F
C
C     EXTRACT TIMING VARIABLES
C
      MYRM=FLD(20,4,D(4))
      MYRC=FLD(24,4,D(4))
      MYRD=FLD(28,4,D(4))
      MYRU=FLD(32,4,D(4))
      MYEAR=1000*MYRM+100*MYRC+10*MYRD+MYRU
      MJOC=FLD(0,4,D(5))
      MJOD=FLD(4,4,D(5))
      MJOU=FLD(8,4,D(5))
      MYRJO=100*MJOC+10*MJOD+MJOU
      MHRD=FLD(12,4,D(5))
      MHRU=FLD(16,4,D(5))
      LH=10*MHRD+MHRU
      MIND=FLD(20,4,D(5))
      MINU=FLD(24,4,D(5))
      MSECD=FLD(28,4,D(5))
      MSECU=FLD(32,4,D(5))
      MSEC=10*MSECD+MSECU
      LM=10*MIND+MINU
C
C     PARITY CHECK
C
      IF(ISTAT.NE.5) GO TO 10
C
C     CHECK IF CALIBRATION RECORD
C
      IF(MSIGN.GT.0) GO TO 13
```

```
      SUBROUTINE READER
C
C     CHECK FOR RIGHT YEAR
C
      IF(MYEAR.EQ.NYEAR) GO TO 8
      IF(LINK(7).EQ.0) WRITE(6,1002) UR,MYEAR,MLIST
 1002 FORMAT(F7.0,11H WRONG YEAR,I6,59X,8I5)
      JMY=JMY+1
      IF(LINK(7).EQ.0) GO TO 90
      GO TO 12
C
    8 MY=MYEAR-(MYEAR/100)*100
      LM=LM+ITCOR
      IF(LM.LT.0) LH=LH-1
      IF(LM.LT.0) LM=60+LM
      IF(LH.LT.0) MYRJO=MYRJO-1
      IF(LH.LT.0) LH=24+LH
      LHCOR=LM/60
      LM=LM-60*LHCOR
      LH=LH+LHCOR
      JOCOR=LH/24
      LH=LH-24*JOCOR
      MYRJO=MYRJO+JOCOR
      IF(MYRJO.NE.N) CALL MONDAY(MYRJO,MO,JO,MON,N)
      RETURN
C
C     READ DIAGNOSTICS
C
    9 IF(LINK(6).NE.0) GO TO 12
   90 CALL PAGE
      WRITE(6,1006) ICAL
      NBITE=NBITE-1
      NBIT=NBIT+1
      IF(JMY.GE.5.OR.JPAR.GE.5) GO TO 14
      GO TO 1
   10 IWRONG=6HREAD
      IF(ISTAT.EQ.-3) IWRONG=6HPARITY
      IF(LINK(7).EQ.0) WRITE(6,1003) UR,IWRONG,ISTAT,MYRJO,L
     *H,LM,MSEC,
     1MLIST
 1003 FORMAT(F7.0,1X,A6,10H ERROR.  (,I3,1H),27X,3HDAY,I5,11
     *H TIME (EST)
     1,2X,3I2,1X,8I5)
      IPAR=IPAR+1
      IF(IPAR.GT.50 ) GO TO 11
      IF(LINK(7).EQ.0) GO TO 90
```

SUBROUTINE READER

```
      GO TO 12
   11 MISS=2
      JSTAT=IABS(ISTAT)
      WRITE(6,1004) ISTAT,ITAPE,(D(I),I=1,JSTAT)
 1004 FORMAT(1X/6H *****,5H LAST,I3,21H WORDS READ FROM UNIT
     *,I3,
     16H WERE ,5(1X,A6),6H *****)
      RETURN
   12 NBIT=NBIT+1
      IF(JMY.GE.5.OR.JPAR.GE.5) GO TO 14
      GO TO 1
C
C     WRITE OUT CALIBRATION RECORD
C
   13 WRITE(6,1005) UR,ICAL,ICAL,MYRJO,LH,LM,MSEC,MLIST,ICAL
 1005 FORMAT(F7.0,6X,A5,5X,19H CALIBRATION RECORD,5X,A5,3X,3
     *HDAY,I5,
     111H TIME (EST),2X,3I2,1X,8I5,A5)
      GO TO 90
C
C     IF IN TROUBLE READING TAPE, FIND NEXT INTER RECORD GAP
     *.
C
   14 CALL NTRAN(ITAPE,7,1)
      CALL NTRAN(ITAPE,22)
      UR=UR+1.0
      NBIT=NBIT+1
      IF(JPAR.GT.5.OR.JMY.GT.5) GO TO 1
      IF(JPAR.EQ.5) JERR=3HP                  @ PARITY ERRORS
      IF(JMY.EQ.5) JERR=3HB                   @ BAD DATA
      WRITE(6,1006) JERR
 1006 FORMAT(1H+,128X,A3)
      GO TO 1
      END
```

```
      SUBROUTINE SOLVE(X,X1,ELL,MZ,MISS)
C
C     USES PHASES DETERMINED FROM ANTENNAE 4 AND 5
C     TO RESOLVE AMBIGUITIES IN L AND M AS DETERMINED  FROM
     *1 AND 3
C
    1 IF(X)2,4,3
    2 X=X+1.0
      GO TO 1
    3 IF(X.LT.1.0) GO TO 4
      X=X-1.0
      GO TO 3
    4 IF(X1)5,7,6
    5 X1=X1+1.0
      GO TO 4
    6 IF(X1.LT.1.0) GO TO 7
      X1=X1-1.0
      GO TO 6
    7 IF((ABS(X-X1)-ELL).LT.0.0) GO TO 8
      IF((ABS(X-X1+1.0)-ELL).LT.0.0) GO TO 9
      IF(ABS(X-X1-1.0)-ELL)10,10,11
    8 AMISS=X-X1
      GO TO 12
    9 AMISS=X-X1+1.0
      GO TO 12
   10 AMISS=X-X1-1.0
      GO TO 12
   11 AMISS=X-X1
      GO TO 13
   12 MZ=1
      GO TO 14
   13 MZ=-1
   14 AMISS=AMISS*100.0
      MISS=AMISS
      RETURN
      END
```

```
      SUBROUTINE MONDAY (MYRDAY,MO,JO,MON,N)
C
C     CONVERTS DAY OF YEAR TO MONTH, DAY, BOTH HOLERITH AND
     *INTEGER.
C     TAKES ACCOUNT OF LEAP YEARS
C
      COMMON UR
      COMMON/YEAR/NYEAR
      COMMON/ERROR/MISS,NBIT,NBITE
C
1     M=MYRDAY
      N=M
      IF(M.GT.31) GO TO 2
      MON=3HJAN
      MO=1
      JO=M
      RETURN
2     KYEAR=(NYEAR/4)*4
      IF(KYEAR.NE.NYEAR) M = M + 1
      IF(M.GT.60) GO TO 3
      MON=3HFEB
      MO=2
      IF(KYEAR.NE.NYEAR) M = M - 1
      JO=M-31
      RETURN
3     IF(M.GT.91) GO TO 4
      MON=3HMAR
      MO=3
      JO=M-60
      RETURN
4     IF(M.GT.121) GO TO 5
      MON=3HAPL
      MO=4
      JO=M-91
      RETURN
5     IF(M.GT.152) GO TO 6
      MON=3HMAY
      MO=5
      JO=M-121
      RETURN
6     IF(M.GT.182) GO TO 7
      MON=3HJUN
      MO=6
      JO=M-152
      RETURN
7     IF(M.GT.213) GO TO 8
```

```
      SUBROUTINE MONDAY (MYRDAY,MO,JO,MON,N)

      MON=3HJLY
      MO=7
      JO=M-182
      RETURN
8     IF(M.GT.244) GO TO 9
      MON=3HAUG
      MO=8
      JO=M-213
      RETURN
9     IF(M.GT.274) GO TO 10
      MON=3HSEP
      MO=9
      JO=M-244
      RETURN
10    IF(M.GT.305) GO TO 11
      MON=3HOCT
      MO=10
      JO=M-274
      RETURN
11    IF(M.GT.335) GO TO 12
      MON=3HNOV
      MO=11
      JO=M-305
      RETURN
12    IF(M.GT.366) GO TO 13
      MON=3HDEC
      MO=12
      JO=M-335
      RETURN
13    WRITE(6,1000) MYRDAY,UR
 1000 FORMAT(40X,25H DAY OF YEAR IN ERROR, = ,I5,F8.0)
      CALL PAGE
      NBITE=NBITE-1
      MON=3H(*)
      MO=13
      JO=M-366
      NBIT=NBIT+1
      IF(NBIT.EQ.500) MISS = 1
      RETURN
      END
```

SUBROUTINE PAGE

```
C
C     TURNS PAGE, NUMBERS IT, AND PRINTS HEADER
C
      COMMON/HSKP/HEADER(12),SOURCE(2),NOP,LINE,LINES
      COMMON/ERROR/MISS,NBIT,NBITE
C
      LINE=LINE+1
      NBITE=NBITE+1
      LINES=LINES+1
      IF(((LINES/5)*5-LINES).EQ.0) WRITE(6,1000)
 1000 FORMAT(1X)
      IF(LINE.LT.40.AND.LINE.NE.0) RETURN
      NOP=NOP+1
      LINE=0
      WRITE(6,1001) HEADER,SOURCE,NOP
 1001 FORMAT(1H1/1X,12A6,2A4,30X,4HPAGE,I4/1X)
      RETURN
      END
```

MAIN PROGRAM (LOADIT)

```
C       PROGRAM GARCHY. FORMAT PROCESSOR.  U1108 VERSION
C       READS GARCHY METEOR WIND DATA
C       WRITES INPUT FILES FOR GROVES, ERG.
C
C       READS DATA IN THE FOLLOWING ORDER
C       HEADER CARD, INCLUDING SOURCE.          FORMAT 12A6,2A4
C       GARCHY SYSTEM DATA CARDS
C       BLANK CARD
C       EOF
C
        DIMENSION SOURCE(2),RESULT(12)
C
        NU4=4
        N4=0
C
        READ(5,999)RESULT,SOURCE
  999   FORMAT(12A6,2A4)
        WRITE(4,999)RESULT,SOURCE
        LEVEL = 6
        MCS = 9
        MX = 0
        RAD=0.017453293
        TWOPI=360.0*RAD
        RAD450=450.0*RAD
        UR=1000.0
    1   READ(5,1001)JO,MO,MY, JTIMH,JTIMM,RANGE,AZ,EL,VEL
 1001   FORMAT(2I3,3X,I2,2I3,4F6.1)
        RAZ=AZ*RAD
C                                                                    ****
      ********************
C       CHANGE GARCHY21 AZIMUTH TO CLOCKWISE FROM NORTH             ****
      ********************
C
        RAZ=RAD450-RAZ
        IF(RAZ.GT.TWOPI)   RAZ=RAZ-TWOPI
        REL=EL*RAD
        EL3=COS(REL)*COS(RAZ)
        EM3=COS(REL)*SIN(RAZ)
        EN3=SIN(REL)
        Z=EN3*RANGE
        LTIMM=JTIMM+12
        IF(LTIMM-60)4,2,2
    2   JTIMH=JTIMH+1
        LTIMM=LTIMM-60
        IF(JTIMH-24)4,3,3
```

MAIN PROGRAM (LOADIT)

```
    3 JO=JO+1
      JTIMH=JTIMH-24
    4 LTIMH=JTIMH
      TIMM=LTIMM
      TIMH=LTIMH
      TIMH=TIMH+TIMM/60.0+0.5
      IF(TIMH.LT.1.0) TIMH = 24.5
      LT=TIMH
      IF(EN3.LT.0.01) EN3=1.0
      NFL=(VEL/EN3)*COS(RAZ)
      NFM=(VEL/EN3)*SIN(RAZ)
      IF(JO.EQ.0) UR=-1.0
      UR=UR+1.0
      WRITE(4)UR,MY,MO,JO,LTIMH,LTIMM,RAZ,REL,EL3,EM3,Z,LEVE
     *L,LT,
     1NFL,NFM,VEL,MCS,MX,SOURCE
      N4=N4+1
      IF(JO.GT.0) GO TO 1
      END FILE 4
      WRITE(6,2000)N4,NU4
 2000 FORMAT(1H1/ 1X,I6,24H RECORDS WRITTEN ON UNIT,I2///)
      STOP
      END
```

MAIN PROGRAM (GROVES)

```
C     GROVES ANALYSIS - UNIVAC 1108 FORTRAN V VERSION.
C     DECK CONSISTS OF
C     MAIN PROGRAM
C     SUBROUTINE DIANA
C     SUBROUTINE VARY
C     SUBROUTINE MATSIN
C     SUBROUTINE MONTH
C     SUBROUTINE PAGE
C     READS INPUT DATA FROM TAPE 5 (SYSTEM INPUT) IN THE FOL
     *LOWING ORDER
C     DATA INTERVAL TO BE PROCESSED,  FORMAT I6,3X,I6
C     STRTDA = START DAY.  6 DIGITS - YEAR MONTH DAY.  69030
     *7 IS MARCH 7, 1969
C     ENDDAY = END DAY,    6 DIGITS - YEAR MONTH DAY.  70052
     *9 IS MAY 29, 1970
C     IF STRTDA-ENDDAY CARD IS BLANK, ALL DATA IN FILE WILL
     *BE PROCESSED.
C     EAST-WEST TIME VARIATION NP, NORTH-SOUTH TIME VARIATIO
     *N NQ,
C     AND VERTICAL TIME VARIATION NR. FORMAT 3I3
C     PERIODICITY OF FUNDAMENTAL TIME VARIATION  FORMAT F7.0
C     HEIGHT RANGE ZMIN, ZMAX. FORMAT I5,I4
C     EAST-WEST HEIGHT PROFILE.     FORMAT 24I3
C     NORTH-SOUTH HEIGHT PROFILE.    FORMAT 24I3
C     VERTICAL HEIGHT PROFILE.       FORMAT 24I3
C     WINDS ARE CONSIDERED HORIZONTAL IF VERTICAL HEIGHT PRO
     *FILE IS
C     DESIGNATED NEGATIVE
C
C     REQUIRES ECHO INPUT DATA ON FASTRAND2 (MASS STORAGE)
C     THIS DATA MUST BE FILED PRIOR TO RUNNING GROVES, USING
     * ONE OF
C     THE *LOADIT* SERIES PROGRAMS.
C     UNIT NTAPE (=4) NEEDS TO BE ASSOCIATED WITH THE APPROP
     *RIATE
C     INPUT DATA FILE BY MEANS OF A   @USE 4,FILENAME   STAT
     *EMENT
C
      INTEGER DATE
      INTEGER STRTDA,ENDDAY,DAY
C
      DIMENSION Q(100,100),A(100,100),R(100,100),P(100),D(10
     *0),AC(100),
     1NA(10),NB(10),NC(10),SUMSA(10),SUMSB(10),SUMSC(10),SIG
     *MA(100),
```

MAIN PROGRAM (GROVES)

```
      2RESULT(12),MNO(30,24),SINJ(10),COSJ(10),SI(96),CO(96),
      *NTIME(24)
       DIMENSION SOURCE(2),WHERE(2)
       DIMENSION DATE(3)
C
       EQUIVALENCE(A,R)
C
       COMMON/INTRVL/STRTDA,ENDDAY,IMY,IMONTH,IJO,JMY,JMONTH,
      *JJO,JUMP
       COMMON A,NOP,ZMIN,MIN,ZMAX,MAX,SI,CO,SUM,NP,NQ,NR,NAO,
      *NBO,NCO,
      1NA,NB,NC,NTIME,AC,RESULT,PERIOD,SOURCE,DATE
C
C      INTERROGATE MACHINE TO DETERMINE DATE OF RUN
C
       CALL ERTRAN(9,IDATE,I)
       DECODE(34,IDATE)DATE
    34 FORMAT(3I2)
       CALL MONTH (DATE(1),DATE(1))
C
C      INITIALIZATION
C
       NBOMB=0
       NEG=0
       NTAPE=4
       NRDERR=0
       DO 302 I=1,96
       J=I
       ANGLE=FLOAT(J)*0.2618
       SI(I)=SIN(ANGLE)
       CO(I)=COS(ANGLE)
   302 CONTINUE
       DO500I=1,24
   500 NTIME(I)=I
       DO38I=1,100
       P(I)=0.0
       AC(I)=0.0
       DO38L=1,100
       Q(I,L)=0.0
    38 CONTINUE
       NUMNA=0
       NUMNB=0
       NUMNC=0
       SUM1=0.0
       SUM2=0.0
```

MAIN PROGRAM (GROVES)

```
      SUM3=0.0
      M=0
      NOP=0
      DO39I=1,10
      NA(I)=0
      NB(I)=0
      NC(I)=0
   39 CONTINUE
      DO41I=1,30
      DO41J=1,24
      MNO(I,J)=0
   41 CONTINUE
C
C     THIS SECTION OF THE PROGRAM READS PROCESSING PARAMETER
     *S.
C
      REWIND NTAPE
      READ(NTAPE,31)RESULT,SOURCE
   31 FORMAT(12A6,2A4)
C
C     SELECT DATA INTERVAL TO BE PROCESSED
C
      READ(5,32,END=299)STRTDA,ENDDAY   @ CONTINGENCY LEVEL 1
     *    *****    LEVEL 1
   32 FORMAT(I6,3X,I6)
      NBOMB=NBOMB+1
      IF(STRTDA.GT.ENDDAY) GO TO 299   @ CONTINGENCY LEVEL 2
     *    *****    LEVEL 2
      IF(ENDDAY.EQ.0) GO TO 6
      JUMP=0
      IMYMO=STRTDA/100
      JMYMO=ENDDAY/100
      IJO=STRTDA-IMYMO*100
      JJO=ENDDAY-JMYMO*100
      IMY=IMYMO/100
      JMY=JMYMO/100
      IMO=IMYMO-IMY*100
      CALL MONTH(IMONTH,IMO)
      JMO=JMYMO-JMY*100
      CALL MONTH(JMONTH,JMO)
      GO TO 7
C
  299 NBOMB=NBOMB+1
      WRITE(6,210)NBOMB
  210 FORMAT(1H1/1X,23HEXIT, CONTINGENCY LEVEL,I2////1X,17HN
```

MAIN PROGRAM (GROVES)

```
     *0 DATA ON TA
     1PE 5)
      STOP
C
    6 JUMP=1
      ENDDAY=1.0E+06
    7 CONTINUE
      READ(5,1)NP,NQ,NR
    1 FORMAT(24I3)
      NPMAX=NP
      IF(NQ.LE.NPMAX) GO TO 60
      NPMAX=NQ
   60 IF(NR.LE.NPMAX) GO TO 61
      NPMAX=NR
   61 CONTINUE
      READ(5,37)PERIOD
   37 FORMAT(F7.0)
      READ(5,2)ZMIN,ZMAX
    2 FORMAT(1X,2F4.0)
      MIN=ZMIN
      MAX=ZMAX
      IF(NP)50,50,51
   50 READ(5,1)NA0
      GO TO 52
   51 READ(5,1)NA0,(NA(J),J=1,NP)
      DO17J=1,NP
   17 NUMNA=NUMNA+NA(J)
   52 IF(NQ)53,53,54
   53 READ(5,1)NB0
      GO TO 55
   54 READ(5,1)NB0,(NB(J),J=1,NQ)
      DO18J=1,NQ
   18 NUMNB=NUMNB+NB(J)
   55 IF(NR)56,56,57
   56 READ(5,1)NC0
      GO TO 58
   57 READ(5,1)NC0,(NC(J),J=1,NR)
C
C     CHECK TO SEE IF WINDS ARE TO BE CONSIDERED HORIZONTAL
C
   58 IF(NC0.GE.0) GO TO 36
      NEG=-1
      NC0=0
      NR=0
      NC(1)=0
```

MAIN PROGRAM (GROVES)

```
C
   36 CONTINUE
      DO19J=1,NR
   19 NUMNC=NUMNC+NC(J)
      N=3+NA0+NB0+NC0+2*(NP+NQ+NR+NUMNA+NUMNB+NUMNC)
      IF(N-100)4,4,3000
 3000 WRITE(6,3001)N
 3001 FORMAT(1H1/1X,9HEXECUTION    /////
     11X,8H     ****,3X,16HDIMENSION OF N (,I4,23H ) EXCEEDS
     *THAT ALLOWED
     2 ////1X,8H     ****3X,29HPROGRAMME CANNOT BE CONTINUED/
     *//)
      STOP
    4 CONTINUE
      NE=N+1
      N2=2*N
C
C     READ DATA, ECHO BY ECHO.
C
    3 READ(NTAPE,ERR=1032,END=1036)UR,MY,MO,JO,LTIMH,LTIMM,E
     *L,EM,
     1EL3,EM3,Z,LEVEL,LT,NFL,NFM,VEL,MCS,MX,WHERE
C
C     CHECK READ STATUS
C
      IF(UR)1036,100,5
 1032 WRITE(6,1034)URHOLD
 1034 FORMAT(1X,34HREAD ERROR AT OR NEAR ECHO NUMBER ,F7.0)
      NRDERR=NRDERR+1
      IF(NRDERR-10)3,3,300
 1036 WRITE(6,1037)URHOLD
 1037 FORMAT(1X,56HNO BLANK CARD AT END OF DATA DECK, OR ILL
     *EGAL DATA CA
     1RD./////1X,43HOUTPUT ATTEMPTED, BUT WATCH OUT FOR ERRO
     *RS./////
     21X,50H     $$$$$     $$$$$     $$$$$     $$$$$     $$$
     *$$ /////
     31X,41HLAST CARD READ CORRECTLY WAS ECHO NUMBER ,F7.0)
      GO TO 100
C
C     DETERMINE  WHETHER ECHO FALLS IN DESIRED HEIGHT/TIME I
     *NTERVAL
C
    5 IF(Z.LT.ZMIN.OR.Z.GT.ZMAX) GO TO 3
      DAY=MY*10000+MO*100+JO
```

```
      IF(DAY.LT.STRTDA) GO TO 3
      IF(DAY.GT.ENDDAY) GO TO 100
C
      M=M+1                                                     @ COUNTS EC
     *HOES USED.
      IF(M.EQ.1)STRTDA=DAY
      URHOLD=UR
C
C     CALCULATE TIME WITH RESPECT TO INPUT PERIODICITY
C
      TMINIT=(JO-1)*1440+LTIMH*60+LTIMM
      THOUR=TMINIT/60.0
      NEWDAY=THOUR/PERIOD
      T=(THOUR/PERIOD-FLOAT(NEWDAY))*6.28318
      DO33J=1,NPMAX
      FJT=FLOAT(J)*T
      SINJ(J)=SIN(FJT)
      COSJ(J)=COS(FJT)
   33 CONTINUE
C
      NZ=Z
      I=(NZ-MIN)/2+1
      IF(LT.EQ.0)LT=24
      MNO(I,LT)=MNO(I,LT)+1
C
C      NEXT COMES PROCESSING OF ECHO DATA TO PRODUCE COLUMNS
     * D AND P,
C     AND MATRIX Q.
C
      DCL=EL3
      DCM=EM3
      DCN=SQRT(1.0-EL3**2-EM3**2)
C
C     CHANGE DIRECTION COSINES AND VELOCITY IF WIND IS TO BE
     * CONSIDERED
C     HORIZONTAL
C
      IF(NEG.NE.-1) GO TO 333
      SINKI=SQRT(1.0-DCN**2)
      DCL=DCL/SINKI
      DCM=DCM/SINKI
      DCN=0.0
      VEL=VEL/SINKI
C
  333 CONTINUE
```

MAIN PROGRAM (GROVES)

```
C
C     CALCULATE NORMALIZED HEIGHT OF ECHO.
C
      S=(2.0*Z-ZMAX-ZMIN)/(ZMAX-ZMIN)   +  1.0E-06
C
      SUMP=0.0
      SUMQ=0.0
      SUMR=0.0
      NCOUNT=0
 1000 NAOT=2*NAO
      SUMSAO=1
      IF(NAOT)110,110,84
   84 DO8K=2,NAOT,2
      SUMSAO=SUMSAO+S**K
    8 CONTINUE
      IF(NP)110,110,85
   85 DO10J=1,NP
      NA2=2*NA(J)
      SUMSA(J)=1
      DO9K=2,NA2,2
    9 SUMSA(J)=SUMSA(J)+S**K
      SUMP=SUMP+SUMSA(J)
   10 CONTINUE
  110 SUMP=SUMP+SUMSAO
      NBOT=2*NBO
      SUMSBO=1
      IF(NBOT)130,130,114
  114 DO11K=2,NBOT,2
      SUMSBO=SUMSBO+S**K
   11 CONTINUE
      IF(NQ)130,130,115
  115 DO13J=1,NQ
      NB2=2*NB(J)
      SUMSB(J)=1
      DO12K=2,NB2,2
   12 SUMSB(J)=SUMSB(J)+S**K
      SUMQ=SUMQ+SUMSB(J)
   13 CONTINUE
  130 SUMQ=SUMQ+SUMSBO
      NCOT=2*NCO
      SUMSCO=1
      IF(NCOT)160,160,135
  135 DO14K=2,NCOT,2
      SUMSCO=SUMSCO+S**K
   14 CONTINUE
```

```
      IF(NR)160,160,145
  145 DO16J=1,NR
      NC2=2*NC(J)
      SUMSC(J)=1.0
      DO15K=2,NC2,2
   15 SUMSC(J)=SUMSC(J)+S**K
      SUMR=SUMR+SUMSC(J)
   16 CONTINUE
  160 SUMR=SUMR+SUMSC0
      WF=1.0/((DCL**2)*SUMP+(DCM**2)*SUMQ+(DCN**2)*SUMR)
      SUM3=SUM3+WF*VEL**2
      NA0E=NA0+1
      DO20K=1,NA0E
      NCOUNT=NCOUNT+1
   20 D(NCOUNT)=DCL*(S**(K-1))
      IF(NP)322,322,320
  320 DO21J=1,NP
      NAE=NA(J)+1
      DO21K=1,NAE
      NCOUNT=NCOUNT+1
   21 D(NCOUNT)=DCL*(S**(K-1))*SINU(J)
      DO22J=1,NP
      NAE=NA(J)+1
      DO22K=1,NAE
      NCOUNT=NCOUNT+1
   22 D(NCOUNT)=DCL*(S**(K-1))*COSU(J)
  322 NB0E=NB0+1
      DO23K=1,NB0E
      NCOUNT=NCOUNT+1
   23 D(NCOUNT)=DCM*(S**(K-1))
      IF(NQ)325,325,323
  323 DO24J=1,NQ
      NBE=NB(J)+1
      DO24K=1,NBE
      NCOUNT=NCOUNT+1
   24 D(NCOUNT)=DCM*(S**(K-1))*SINU(J)
      DO25J=1,NQ
      NBE=NB(J)+1
      DO25K=1,NBE
      NCOUNT=NCOUNT+1
   25 D(NCOUNT)=DCM*(S**(K-1))*COSU(J)
  325 NC0E=NC0+1
      DO26K=1,NC0E
      NCOUNT=NCOUNT+1
   26 D(NCOUNT)=DCN*(S**(K-1))
```

```
      IF(NR)328,328,326
  326 DO27J=1,NR
      NCE=NC(J)+1
      DO27K=1,NCE
      NCOUNT=NCOUNT+1
   27 D(NCOUNT)=DCN*(S**(K-1))*SINJ(J)
      DO28J=1,NR
      NCE=NC(J)+1
      DO28K=1,NCE
      NCOUNT=NCOUNT+1
   28 D(NCOUNT)=DCN*(S**(K-1))*COSJ(J)
  328 DO29J=1,N
      P(J)=P(J)+WF*VEL*D(J)
   29 CONTINUE
      DO30J=1,N
      DO30K=1,N
      Q(J,K)=Q(J,K)+WF*D(J)*D(K)
   30 CONTINUE
      GO TO 3
C
C     PRELIMINARY OUTPUT.
C
  100 CALL PAGE (RESULT,SOURCE,DATE)
      ENDDAY=DAY
      WRITE(6,200)STRTDA,ENDDAY
  200 FORMAT(1X,14H DATA INTERVAL,3X,I6,4H  TO,I8///
     1              1X,48H VARIATION OF UPPER ATMOSPHERE WIND
     *S WITH HEIGH
     1T    ,42H  GROVES ANALYSIS,WITH ERROR DETERMINATION)
      WRITE(6,201)M,N,        NP,NQ,NR,MAX,MIN,NAO,NA,NBO,NB,N
     *CO,NC,PERIOD
  201 FORMAT(1X/// 1X,32H NUMBER OF METEORS PROCESSED    =,I5
     *////1X,33H N
     1UMBER OF INPUT PARAMETERS      = ,I4,////1X,33H DATA REA
     *D FROM MASS
     2STORAGE FILE,////1X,27H TIME SERIES PARAMETERS P =,I4,
     *6H,  Q =,I4,
     36H,  R =,I4////1X,27H HEIGHT RANGE,     MAXIMUM  ,I5,1X
     *,11H  MINIMU
     4M  ,I5,///1X,24H POWER SERIES PARAMETERS///29X,2HNA,11
     *I3//29X,
     52HNB,11I3//29X,2HNC,11I3/////1X,6HPERIOD,F7.1,6H HOURS
     *)
C
C     ECHO RATE AS A FUNCTION OF TIME AND HEIGHT.
```

MAIN PROGRAM (GROVES)

```
C
      CALL PAGE (RESULT,SOURCE,DATE)
      WRITE(6,4000)NTIME
 4000 FORMAT(1X,44H ECHO RATE AS A FUNCTION OF TIME AND HEIG
     *HT.////
     11X,7H HEIGHT,24I5/1X)
      NH=(MAX-MIN)/2
      DO4002K=1,NH

     *       :86;R\ΔI
      NZ=MAX-2*K+1
 4002 WRITE(6,4001)NZ,(MNO(I,J),J=1,24)
 4001 FORMAT(1X,I5,2X,24I5/1X)
C
      IF(M.GT.120) GO TO 400
      NBOMB=3                                   @ CONTINGENCY LEVEL 3
     *    *****    LEVEL 3
      GO TO 1102
C
C     INVERSION OF Q, AND FORMATION OF COEFFICIENT COLUMN AC
     *.
C
  400 CONTINUE
      DO101J=1,N
      DO101K=1,N
      A(J,K)=Q(J,K)
  101 CONTINUE
      NBOMB=4                                   @ CONTINGENCY LEVEL 4
     *    *****    LEVEL 4
      CALLMATSIN(A,N,DETERM)
      IF(DETERM.GT.-12.0) GO TO 1103
 1102 WRITE(6,1104) RESULT,N,N,DETERM,NBOMB
 1104 FORMAT(1H1/1X,12A6////1X,52H **** ERROR IN INPUT DATA
     *HAS RESULTED
     1 IN MATRIX  Q(I3,1H,I3,34H ) BEING UNSUITABLE FOR INVE
     *RSION./////
     2 10X,50H      $$$$$      $$$$$      $$$$$      $$$$$      $
     *$$$$ /////
     31X,13H DETERMINANT ,E12.4///1X,18H CONTINGENCY LEVEL,I
     *5///
     41X,30HPROGRAMME CANNOT BE CONTINUED.)
      STOP
C
C     FORMULATE MODEL COEFFICIENTS ( AC )
C
```

MAIN PROGRAM (GROVES)

```
 1103 CONTINUE
      DO103K=1,N
      DO103J=1,N
      AC(K)=AC(K)+P(J)*R(J,K)
  103 CONTINUE
      DO104J=1,N
      DO104K=1,N
      SUM1=SUM1+AC(J)*AC(K)*Q(J,K)
  104 CONTINUE
      DO105J=1,N
      SUM2=SUM2+AC(J)*P(J)
  105 CONTINUE
      SUM=(SUM1-(2.0*SUM2)+SUM3)/FLOAT(M-N)
      DO106J=1,N
      CHECK=R(J,J)*SUM
      ACHECK=ABS(CHECK)+0.01
      SIGN=CHECK/ACHECK
  106 SIGMA(J)=SIGN*SQRT(ACHECK)
C
C     OUTPUT
C
      CALL PAGE (RESULT,SOURCE,DATE)
      WRITE(6,35)DETERM
   35 FORMAT(1X,36H LOG (BASE 10) OF MATRIX DETERMINANT,E13.
     *6/1X)
      WRITE(6,206)
  206 FORMAT(1X,25H COLUMN MATRIX AC(K)          /1X)
      J=0
      DO205I=1,N
      J=J+1
      IF(J-45)208,208,207
  207 J=0
      CALL PAGE (RESULT,SOURCE,DATE)
      WRITE(6,206)
  208 WRITE(6,209)AC(I),SIGMA(I)
  209 FORMAT(26X,F7.2,3X,F7.1)
  205 CONTINUE
      PUNCH 1234, (AC(IOUT),IOUT=1,100)
 1234 FORMAT(8F10.3)
      IF(PERIOD-24.0)404,403,404
C
C     CALCULATE AND PRINT OUT 24 HOUR HEIGHT / TIME PROFILES
C
  403 CALL DIANA
  404 CONTINUE
```

MAIN PROGRAM (GROVES)

```
C
C     CALCULATE AND PRINT OUT AMPLITUDE AND PHASE VARIATIONS
     * WITH HEIGHT
C
      CALL VARY
  300 STOP
      END
```

```
      SUBROUTINE DIANA
C
C       PRINTS OUT HOUR BY HOUR WIND PROFILES IF FUNDAMENTAL P
     *ERIOD = 24 HOURS
C
      DIMENSION A(100,100),R(100,100),SI(96),CO(96),NA(10),N
     *B(10),NC(10)
     1,AC(100),U(24),RESULT(12),NTIME(24),NANEW(10)
      DIMENSION SOURCE(2)
      DIMENSION DATE(3)
      EQUIVALENCE(A,R)
      COMMON A,NOP,ZMIN,MIN,ZMAX,MAX,SI,CO,SUM,NP,NQ,NR,NAO,
     *NBO,NCO,
     1NA,NB,NC,NTIME,AC,RESULT,PERIOD,SOURCE,DATE
C
C       EAST-WEST WIND COMPONENT, HOUR BY HOUR.
C
      CALL PAGE (RESULT,SOURCE,DATE)
      WRITE(6,597)MIN,MAX
  597 FORMAT(1X,52HEAST-WEST COMPONENTS OF THE MEAN WIND, HO
     *UR BY HOUR,/
     1/1X,34HAS DETERMINED FOR THE HEIGHT RANGE,I5,6H KM TO,
     *I5,4H KM.///
     2//)
      WRITE(6,600)NTIME
  600 FORMAT(1X,6HHEIGHT,24I5/1X)
      DO128J=1,NP
  128 NANEW(J)=NA(J)
      NPNEW=NP
      KEND=0
      NAOE=NAO+1
      NBOE=NBO+1
      NCOE=NCO+1
      NSIGN=-1
  105 KA=KEND
      DO307KZ=MIN,MAX,2
      UO=0.0
      DO303LT=1,24
  303 U(LT)=0.0
      Z=MAX+MIN-KZ
      NZ=Z
      S=(2.0*Z-ZMAX-ZMIN)/(ZMAX-ZMIN)+ 1.0E-06
      DO304K=1,NAOE
      KUA=K+KA
  304 UO=UO+AC(KUA)*S**(K-1)
      IF(NPNEW)310,310,308
```

SUBROUTINE DIANA

```
  308 DO306LT=1,24
      KEND=KA+NAOE
      DO305J=1,NPNEW
      KSTART=KEND
      NAEND=NANEW(J)+1
      KEND=KSTART+NAEND
      JLT=J*LT
      DO305K=1,NAEND
      KU=K+KSTART
  305 U(LT)=U(LT)+AC(KU)*S**(K-1)*SI(JLT)
      DO312J=1,NPNEW
      KSTART=KEND
      NAEND=NANEW(J)+1
      KEND=KSTART+NAEND
      JLT=J*LT
      DO312K=1,NAEND
      KU=K+KSTART
  312 U(LT)=U(LT)+AC(KU)*S**(K-1)*CO(JLT)
      U(LT)=U(LT)+UO
      IF(ABS(U(LT))-999.0)306,306,309
  309 U(LT)=SIGN(999.0,U(LT))
  306 CONTINUE
      GO TO 307
  310 KEND=KA+NAOE
      U(1)=UO
      IF(ABS(U(1))-999.0)107,107,311
  311  U(1)=SIGN(999.0,U(1))
  107 DO108LT=2,24
  108 U(LT)=U(1)
  307 WRITE(6,888)NZ,U
  888 FORMAT(1X,I4,3X,24F5.0/1X)
      IF(NSIGN)129,131,133
C
C     NORTH-SOUTH WIND COMPONENTS, HOUR BY HOUR.
C
  129 NAOE=NBOE
      NPNEW=NQ
      DO130J=1,NQ
  130 NANEW(J)=NB(J)
      NSIGN=0
      CALL PAGE (RESULT,SOURCE,DATE)
      WRITE(6,598)MIN,MAX
  598 FORMAT(1X,54HNORTH-SOUTH COMPONENTS OF THE MEAN WIND,
     *HOUR BY HOUR
     1,//1X,34HAS DETERMINED FOR THE HEIGHT RANGE,I5,6H KM T
```

SUBROUTINE DIANA

```
     *0,I5,4H KM./
     2///)
      WRITE(6,600)NTIME
      GO TO 105
C
C     VERTICAL WIND COMPONENTS, HOUR BY HOUR.
C
  131 NAOE=NCOE
      NPNEW=NR
      DO132J=1,NR
  132 NANEW(J)=NC(J)
      NSIGN=1
      CALL PAGE (RESULT,SOURCE,DATE)
      WRITE(6,599)MIN,MAX
  599 FORMAT(1X,52HVERTICAL COMPONENT OF THE MEAN WIND, HOUR
     * BY HOUR,
     1//1X,34HAS DETERMINED FOR THE HEIGHT RANGE,I5,6H KM TO
     *,I5,4H KM.//
     3//)
      WRITE(6,600)NTIME
      GO TO 105
  133 RETURN
      END
```

SUBROUTINE VARY

```
C
C
C     CALCULATES THE AMPLITUDE AND PHASE OF PREVAILING AND P
     *ERIODIC
C     COMPONENTS, UP TO THE FOURTH HARMONIC,
C     TOGETHER WITH THE MOST PROBABLE ERROR IN EACH.
C     PRINTS THESE OUT AT 2 KM INTERVALS OVER THE HEIGHT RAN
     *GE SPECIFIED.
C
      DIMENSION A(100,100),R(100,100),DUMMY(192),NA(10),NB(1
     *0),NC(10),
     1NTIME(24),AC(100),SI(10),CO(10),AU(10),PH(10),SIGSIN(1
     *0),
     2SIGSC(10),SIGCOS(10),SIGPH(10),SIGAMP(10),ERPH(10),ERA
     *MP(10),
     3PTEM(4),RESULT(12)
      DIMENSION SOURCE(2)
      DIMENSION DATE(3)
      EQUIVALENCE (A,R)
      COMMON A,NOP,ZMIN,MIN,ZMAX,MAX,DUMMY,SUM,NP,NQ,NR,NAO,
     *NBO,NCO,
     1NA,NB,NC,NTIME,AC,RESULT,PERIOD,SOURCE,DATE
      NAOE=NAO+1
      NBOE=NBO+1
      NCOE=NCO+1
      KEND=0
      DO86J=1,4
      PTEM(J)=PERIOD/FLOAT(J)
   86 CONTINUE
      NSIGN=-1
      CALL PAGE (RESULT,SOURCE,DATE)
      WRITE(6,597)MIN,MAX
  597 FORMAT(1X,59HEAST-WEST COMPONENTS OF THE MEAN WIND, AM
     *PLITUDE AND
     1PHASE,//1X,34HAS DETERMINED FOR THE HEIGHT RANGE,I5,6H
     * KM TO,I5,
     24H KM.///)
   98 IF(NP)89,89,88
   89 WRITE(6,87)
   87 FORMAT(1X,18HHEIGHT  MEAN ERROR/1X)
      GO TO 105
   88 GO TO (99,99,101,103),NP
   99 WRITE(6,100)(PTEM(J),J=1,2)
  100 FORMAT(22X,F6.1,15H HOUR COMPONENT,3X,F9.1,15H HOUR CO
     *MPONENT//1X,
```

SUBROUTINE VARY

```
   175HHEIGHT   MEAN     ERROR  AMP    ERROR PHASE    ERROR  A
   *MP   ERROR P
   2HASE    ERROR/1X)
    GO TO 105
101 WRITE(6,102)(PTEM(J),J=1,3)
102 FORMAT(22X,F6.1,15H HOUR COMPONENT,3X,F9.1,15H HOUR CO
   *MPONENT,3X,
   1F9.1,15H HOUR COMPONENT//
   *          1X,1
   202HHEIGHT   MEAN     ERROR  AMP    ERROR PHASE    ERROR  A
   *MP   ERROR P
   3HASE    ERROR  AMP    ERROR PHASE    ERROR/1X)
    GO TO 105
103 WRITE(6,104)(PTEM(J),J=1,4)
104 FORMAT(22X,F6.1,15H HOUR COMPONENT,3X,F9.1,15H HOUR CO
   *MPONENT,3X,
   1F9.1,15H HOUR COMPONENT,3X,F9.1,15H HOUR COMPONENT//1X
   *,         1
   229HHEIGHT   MEAN     ERROR  AMP    ERROR PHASE    ERROR  A
   *MP   ERROR P
   3HASE    ERROR  AMP    ERROR PHASE    ERROR  AMP    ERROR P
   *HASE    ERROR
   4/1X)
105 KA=KEND
    DO128KZ=MIN,MAX,2
    UO=0.0
    Z=MAX+MIN-KZ
    NZ=Z
    S=(2.0*Z-ZMAX-ZMIN)/(ZMAX-ZMIN) + 1.0E-06
    DO106K=1,NAOE
    KUA=K+KA
106 UO=UO+AC(KUA)*S**(K-1)
    SIGUO=0.0
    DO107K=1,NAOE
    DO107L=1,NAOE
    KS=K+KA
    LS=L+KA
107 SIGUO=SIGUO+S**(K-1)*S**(L-1)*R(KS,LS)*SUM
    ASIGUO=ABS(SIGUO) + 0.01
    SIGN=SIGUO/ASIGUO
    EO=SIGN*SQRT(ASIGUO)
    IF(NP)126,126,108
108 KEND=KA+NAOE
    NUMNA=0
    DO109J=1,NP
```

SUBROUTINE VARY

```
      SI(J)=0.0
      CO(J)=0.0
      SIGSIN(J)=0.0
      SIGSC(J)=0.0
      SIGCOS(J)=0.0
      NUMNA=NUMNA+NA(J)
  109 CONTINUE
      DO121J=1,NP
      NUSIN=NP+NUMNA
      KSTART=KEND
      NAEND=NA(J)+1
      KEND=KSTART+NAEND
      DO110K=1,NAEND
      KS=K+KSTART
      SI(J)=SI(J)+AC(KS)*S**(K-1)
      KC=KS+NUSIN
  110 CO(J)=CO(J)+AC(KC)*S**(K-1)
      SINSQJ=SI(J)**2
      COSSQJ=CO(J)**2
      SUMSQJ=SINSQJ+COSSQJ
      AU(J)=SQRT(SUMSQJ)
      FJ=J
      FJ=PERIOD/FJ
      IF(CO(J))114,111,115
  111 IF(SI(J))113,113,112
  112 PH(J)=FJ/4.0
      GO TO 116
  113 PH(J)=FJ*0.75
      GO TO 116
  114 PH(J)=FJ*0.5+(FJ/6.28318)*ATAN(SI(J)/CO(J))
      GO TO 116
  115 PH(J)=(FJ/6.28318)*ATAN(SI(J)/CO(J))
  116 IF(PH(J))117,118,118
  117 PH(J)=FJ+PH(J)
  118 DO119K=1,NAEND
      DO119L=1,NAEND
      KS=K+KSTART
      LS=L+KSTART
      KC=KS+NUSIN
      LC=LS+NUSIN
      SIGSIN(J)=SIGSIN(J)+S**(K-1)*S**(L-1)*R(KS,LS)
      SIGSC(J)=SIGSC(J)+S**(K-1)*S**(L-1)*R(KS,LC)
  119 SIGCOS(J)=SIGCOS(J)+S**(K-1)*S**(L-1)*R(KC,LC)
      PROD=2.0*SI(J)*CO(J)*SIGSC(J)
      SIGPH(J)=(COSSQJ*SIGSIN(J)+SINSQJ*SIGCOS(J)-PROD)*SUM/
```

SUBROUTINE VARY

```
     *SUMSQJ**2
      SIGAMP(J)=(SINSQJ*SIGSIN(J)+COSSQJ*SIGCOS(J)+PROD)*SUM
     */SUMSQJ
      ERPH(J)=SQRT(SIGPH(J))*FJ/6.28318
  121 ERAMP(J)=SQRT(SIGAMP(J))
      KEND=KEND+NUSIN
      GO TO (122,122,124,125),NP
  122 WRITE(6,123)NZ,U0,E0,(AU(J),ERAMP(J),PH(J),ERPH(J),J=1
     *,2)
  123 FORMAT(1X,I4,2X,F6.0,4(1X,2F6.0,2F7.1))
      GO TO 28
  124 WRITE(6,123)NZ,U0,E0,(AU(J),ERAMP(J),PH(J),ERPH(J),J=1
     *,3)
      GO TO 28
  125 WRITE(6,123)NZ,U0,E0,(AU(J),ERAMP(J),PH(J),ERPH(J),J=1
     *,4)
      GO TO 28
  126 WRITE(6,123)NZ,U0,E0
      KEND=KA+NAOE
   28 WRITE(6,23)
   23 FORMAT(1X)
  128 CONTINUE
      IF(NSIGN)129,131,133
  129 NAOE=NBOE
      NP=NQ
      DO130J=1,NQ
  130 NA(J)=NB(J)
      NSIGN=0
      CALL PAGE (RESULT,SOURCE,DATE)
      WRITE(6,598)MIN,MAX
  598 FORMAT(1X,60HNORTH-SOUTH COMPONENTS OF THE MEAN WIND,
     *AMPLITUDE AN
     1D PHASE//1X,34HAS DETERMINED FOR THE HEIGHT RANGE,I5,6
     *H KM TO,I5,
     24H KM.///)
      GO TO 98
  131 NAOE=NCOE
      NP=NR
      DO132J=1,NR
  132 NA(J)=NC(J)
      NSIGN=1
      CALL PAGE (RESULT,SOURCE,DATE)
      WRITE(6,599)MIN,MAX
  599 FORMAT(1X,59HVERTICAL   COMPONENTS OF THE MEAN WIND, A
     *MPLITUDE AND
```

```
      SUBROUTINE VARY
```

```
    1 PHASE//1X,34HAS DETERMINED FOR THE HEIGHT RANGE,I5,6H
    * KM TO,I5,
    24H KM.///)
      GO TO 98
  133 WRITE(6,85)
   85 FORMAT(1H1/)
      RETURN
      END
```

```
      SUBROUTINE MATSIN (A,N,DETERM)
C
C     MATRIX INVERSION, TO 100 X 100
C
      DIMENSION IPIVOT(100),A(100,100),INDEX(100,2),PIVOT(10
     *0)
      EQUIVALENCE (IROW,JROW),(ICOLUM,JCOLUM),(AMAX,T,SWAP)
C
C     INITIALIZATION
C
      ZERO=0.0
      DETERM=ZERO
   15 DO20J=1,N
   20 IPIVOT(J)=0
C
C     SEARCH FOR PIVOT ELEMENT
C
   30 DO550I=1,N
   40 AMAX=0.0
   45 DO105J=1,N
   50 IF(IPIVOT(J)-1)60,105,60
   60 DO100K=1,N
   70 IF(IPIVOT(K)-1)80,100,740
   80 IF(ABS(AMAX)-ABS(A(J,K)))85,100,100
   85 IROW=J
   90 ICOLUM=K
   95 AMAX=A(J,K)
  100 CONTINUE
  105 CONTINUE
  110 IPIVOT(ICOLUM)=IPIVOT(ICOLUM)+1
C
C     INTERCHANGE ROWS TO PUT PIVOT ELEMENT ON DIAGONAL
C
  130 IF(IROW-ICOLUM)140,260,140
  140 DETERM=-DETERM
  150 DO200L=1,N
  160 SWAP=A(IROW,L)
  170 A(IROW,L)=A(ICOLUM,L)
  200 A(ICOLUM,L)=SWAP
  260 INDEX(I,1)=IROW
  270 INDEX(I,2)=ICOLUM
  310 PIVOT(I)=A(ICOLUM,ICOLUM)
      ABSPIV=ABS(PIVOT(I))
      IF(ABSPIV.GT.ZERO) GO TO 320
      DETERM=-13.0
      RETURN
```

```
      SUBROUTINE MATSIN (A,N,DETERM)



  320 DETERM=DETERM+ALOG10(ABSPIV)
      IF(DETERM.GT.-12.0) GO TO  330
      RETURN
C
C     DIVIDE PIVOT ROW BY PIVOT ELEMENT
C
  330 A(ICOLUM,ICOLUM)=1.0
  340 DO350L=1,N
  350 A(ICOLUM,L)=A(ICOLUM,L)/PIVOT(I)
C
C     REDUCE NON-PIVOT ROWS
C
  380 DO550L1=1,N
  390 IF(L1-ICOLUM)400,550,400
  400 T=A(L1,ICOLUM)
  420 A(L1,ICOLUM)=0.0
  430 DO450L=1,N
  450 A(L1,L)=A(L1,L)-A(ICOLUM,L)*T
  550 CONTINUE
C
C     INTERCHANGE COLUMNS
C
  600 DO710I=1,N
  610 L=N+1-I
  620 IF(INDEX(L,1)-INDEX(L,2))630,710,630
  630 JROW=INDEX(L,1)
  640 JCOLUM=INDEX(L,2)
  650 DO705K=1,N
  660 SWAP=A(K,JROW)
  670 A(K,JROW)=A(K,JCOLUM)
  700 A(K,JCOLUM)=SWAP
  705 CONTINUE
  710 CONTINUE
  740 RETURN
      END
```

```
      SUBROUTINE PAGE (RESULT,SOURCE,DATE)
C
C     TURNS PAGE, NUMBERS IT, AND WRITES HEADING AS APPEARIN
     *G
C     ON RESULT CARD.
C
      INTEGER DATE
      DIMENSION A(100,100),RESULT(12)
      DIMENSION SOURCE(2),DATE(3)
C
      COMMON/INTRVL/STRTDA,ENDDAY,IMY,IMONTH,IJO,JMY,JMONTH,
     *JJO,JUMP
      COMMON A,NOP
C
      NOP=NOP+1
      WRITE(6,1)RESULT,DATE,SOURCE,NOP
    1 FORMAT(1H1/1X,12A6,5X,6HRUN ON ,A4,I3,4H, 19,I2,6X,2A4
     *,2X,4HPAGE,
     1I5/1X)
      IF(JUMP.EQ.1) GO TO 3
      WRITE(6,2)IMONTH,IJO,IMY,JMONTH,JJO,JMY
    2 FORMAT(1X,A4,I3,4H, 19,I2,3H TO,A4,I3,4H, 19,I2/1X)
      RETURN
    3 WRITE(6,4)
    4 FORMAT(19H (ALL DATA IN FILE)/1X)
      RETURN
      END
```

```
      SUBROUTINE MONTH(NMONTH,NMO)
C
C     REPLACES NUMERICAL MONTH WORD WITH APPROPRIARE HOLERIT
     *H WORD
C     TRANSFERS * IF NMO.LT.1.OR.GT.12
C
      IF(NMO.LT.1.OR.NMO.GT.12) GO TO 13
      GO TO (1,2,3,4,5,6,7,8,9,10,11,12),NMO
    1 NMONTH=4H JAN
      GO TO 14
    2 NMONTH=4H FEB
      GO TO 14
    3 NMONTH=4H MAR
      GO TO 14
    4 NMONTH=4H APL
      GO TO 14
    5 NMONTH=4H MAY
      GO TO 14
    6 NMONTH=4H JUN
      GO TO 14
    7 NMONTH=4H JLY
      GO TO 14
    8 NMONTH=4H AUG
      GO TO 14
    9 NMONTH=4H SEP
      GO TO 14
   10 NMONTH=4H OCT
      GO TO 14
   11 NMONTH=4H NOV
      GO TO 14
   12 NMONTH=4H DEC
      GO TO 14
   13 NMONTH=4H *
   14 RETURN
      END
```

MAIN PROGRAM (ERG)

```
C     ERG (ELFORD,ROPER,GROVES) METEOR WIND SPECTRUM ANALYSI
     *S.
C
C     ROUTINE SPECTRUM ANALYSIS, FOR GEORGIA TECH U1108.
C     OPTIMIZED DATA HANDLING FORTRAN V PROGRAM,    026 PUNCH
     *.
C     DATA OUTPUT FROM *LOADIT* TO BE ON FASTRAN  (USE UNIT
     *4)
C     MAXIMUM OF 5000 ECHOES WILL BE READ
C
C     DATA ON TAPE 5 CONSISTS OF
C     DATA INTERVAL  STRTDA,ENDDAY  FORMAT I6,3X,I6.
C     HEIGHT RANGE, ZMIN-ZMAX. FORMAT 1X2F4.0
C     PROFILE SPECIFICATIONS NA0,NA,NB0,NB,NC0,NC     FORMAT
     * 16I5
C     NEXT CARD NORMALLY HAS A ZERO OR BLANK IN COLUMN 1. IF
     * SEVERAL
C     SEGMENTS OF A SPECTRUM ARE REQUIRED, A 1 IS PUNCHED IN
     * COLUMN 1.
C     STARTING FREQUENCY FOR PERIODOGRAM, IN CYCLES/DAY (NOR
     *MALLY 0.5),
C     END FREQUENCY (NORMALLY 4.0), AND THE FREQUENCY INCREM
     *ENT
C     (NORMALLY 0.05). FORMAT I1,3F5.2
C     IF A 1 HAS BEEN PUNCHED IN COLUMN 1 OF THE FREQUENCY R
     *ANGE
C     AND INCREMENT CARD, THEN FURTHER CARDS SPECIFYING THE
     *SPECTRUM
C     INTERVALS AND INCREMENTS FOLLOW, EACH WITH A 1 IN COLU
     *MN 1.
C     THE LAST OF THESE CARDS (IF ANY) MUST CONTAIN A ZERO O
     *R BLANK
C     IN COLUMN 1 TO TRIGGER EXIT.
C
C     ANY COMPLETE SET OF CARDS ABOVE MAY BE FOLLOWED BY ANO
     *THER
C     SET, COMMENCING FROM, AND INCLUDING, @XQT ERG.XQT, DAT
     *A INTERVAL CARD, ETC
C     WRITES OUTPUT ON FASTRAND (USE UNIT 16).
C
      INTEGER DATE,STRTDA,ENDDAY,DAY,DAYEND
      DIMENSION WHEN(2)
      DIMENSION RESULT (12),KHT(20)
      DIMENSIONQ (27,27),A (27,54),R (27,27),P (27),D (27),A
     *C (27)
```

MAIN PROGRAM (ERG)

```
      DIMENSION SIGMA (27)
      DIMENSION LTHMM(5000),EL3M(5000),EM3M(5000)   ,ZM(5000)
     *,VELM(5000),
     1JOM (5000),SOURCE (2),DATE (3)
      DIMENSION FINIS(126)
      COMMON A,R,NOP,ZMIN,MIN,ZMAX,MAX,SUM,NP,NQ,NR,NA0,NB0,
     *NC0,
     1NA,NB,NC, AC,RESULT,PERIOD
      COMMON KHT,NHT,MY,MO
      COMMON /IOCHK/NRECB6
      COMMON/INTRVL/STRTDA,ENDDAY,IMY,IMONTH,IJO,JMY,JMONTH,
     *JJO,JUMP,
     1SOURCE,DATE,FREQ
C
C     INTERROGATE MACHINE FOR RUN DATE
C
      CALL ERTRAN (9,IDATE,I)
      DECODE (34,IDATE) DATE
   34 FORMAT (3I2)
      CALL MONTH(DATE(1),DATE(1))
C
C     THIS SECTION OF THE PROGRAMME READS PROCESSING PARAMET
     *ERS.
C
      NRECB6=0
      IPRINT=0
      LOAD=-1
      M=0
      ZERO=0.0
      NPASS=0
      NOGO=0
      NOP=0
      JOMO=0
C
      REWIND 4
      READ(4,31)RESULT,SOURCE
   31 FORMAT(12A6,2A4)
C
C     SELECT DATA INTERVAL TO BE PROCESSED
C
      READ (5,32) STRTDA,ENDDAY
   32 FORMAT (I6,3X,I6)
      IF(STRTDA.GT.ENDDAY) GO TO 1102
      IF(ENDDAY.EQ.0) GO TO 6
      JUMP=0
```

MAIN PROGRAM (ERG)

```
      GO TO 7
    6 JUMP=1
      ENDDAY=2.0E+06
    7 CONTINUE
      NP=1
      NQ=1
      NR=1
C
C     DETERMINE HEIGHT RANGE REQUIRED
C
      READ (5,2) ZMIN,ZMAX
    2 FORMAT (1X2F4.0)
      MIN=ZMIN
      MAX=ZMAX
      IF(MIN.GT.MAX) GO TO 40
      IF(ZMAX-ZMIN-31.0) 39,39,40
   40 WRITE(6,41) MIN,MAX
   41 FORMAT(1X,26H HEIGHT RANGE INCONSISTENT////2I6////
     11X,22H EXECUTION TERMINATED.//////)
      GOTO 300
   39 KHT(1)=MIN
      NHT=(ZMAX-ZMIN)/2.0+1.0
C
C     READ PROFILE SPECIFICATION PARAMETERS
C
      READ(5,391) NA0,NA,NB0,NB,NC0,NC
  391 FORMAT(16I5)
C
C     READ SPECTRUM INTERVAL PARAMETERS
C
  865 READ(5,866) IBIT,START,ENDIT,STEP
  866 FORMAT(I1,3F5.2)
      IF(IBIT.GT.1) GO TO 333
      IF(START.GT.ENDIT) GO TO 333
      IF(STEP.LT.0.01) GO TO 333
      NUMPAS=(ENDIT-START)/STEP+1.6
      ENDIT=ENDIT-0.0001
      CYCLE=START-STEP
C
      LOAD=LOAD+1
      IF(LOAD) 700,700,1
  700 DO70I=2,NHT
      KHT(I)=KHT (I-1)+2
   70 CONTINUE
C
```

MAIN PROGRAM (ERG)

```
      N=3+NA0+NB0+NC0+2*(NP+NQ+NR+NA+NB+NC)
      IF(N.LE.27.AND.N.GE.9) GO TO 73
      CALL PAGE(RESULT,ZERO)
      WRITE(6,74) N
   74 FORMAT(//////1X,4H N =,I3,23H, EXECUTION TERMINATED.//
     *////)
      STOP
   73 NE=N+1
      N2=2*N
      NAHOLD=NA
      NA0E=NA0+1
      NA0T=2*NA0
      NAE=NA+1
      NA2=2*NA
      NB0E=NB0+1
      NB0T=2*NB0
      NBE=NB+1
      NB2=2*NB
      NC0E=NC0+1
      NC0T=2*NC0
      NCE=NC+1
      NC2=2*NC
C
C
      REWIND 16
    1 IF(LOAD.GT.0) GO TO 998
    3 READ (4)UR,MP,MQ,JO,LTIMH,LTIMM,EL,EM,EL3,EM3,Z,LEVEL,
     *LT,
     1NFL,NFM,VEL,MCS,MX,WHEN
      IF(UR) 999,999,5
    5 DAY=MP*10000+MQ*100+JO
      IF (DAY.LT.STRTDA ) GO TO 3
      IF ( DAY.GT.ENDDAY ) GO TO 999
      IF(Z.LT.ZMIN.OR.Z.GT.ZMAX) GO TO 3
      M=M+1
      IF(MQ.NE.MO.AND.M.GT.1) JOMO=JOM(M-1)
      IF(M.EQ.1) STRTDA=DAY
      IF(M.EQ.5000) GO TO 999
      MY=MP
      MO=MQ
      JOM(M)=JOMO+JO
      LTHMM(M) = LTIMH*100+LTIMM
      EL3M(M) = EL3
      EM3M(M) = EM3
      ZM(M) = Z
```

```
      VELM (M) =VEL
      DAYEND=DAY
      GOTO 3
  999 ENDDAY=DAYEND
      IMYMO=STRTDA/100
      JMYMO=ENDDAY/100
      IJO=STRTDA-IMYMO*100
      JJO=ENDDAY-JMYMO*100
      IMY=IMYMO/100
      JMY=JMYMO/100
      IMO=IMYMO-IMY*100
      CALL MONTH (IMONTH,IMO)
      JMO=JMYMO-JMY*100
      CALL MONTH (JMONTH,JMO)
      WRITE(16) RESULT,KHT(1),NHT,SOURCE,NUMPAS,DATE,IBIT,ST
     *ART,ENDIT,
     1STEP,IMONTH,IJO,IMY,JMONTH,JJO,JMY
      NRECB6=NRECB6+1
  998 CYCLE=CYCLE+STEP
      FREQ=CYCLE
      PERIOD=24.0/FREQ
      NA=NAHOLD
      DO38I=1,N
      P(I) = 0.0
      AC(I) = 0.0
      DO38L=1,N
      Q(I,L) = 0.0
   38 CONTINUE
      SUM1 = 0.0
      SUM2 = 0.0
      SUM3 = 0.0
C
C     NEXT COMES PROCESSING OF ECHO DATA TO PRODUCE COLUMNS
     *D AND P,
C     AND MATRIX Q.
C
      IRUN = 0
   60 IRUN = IRUN + 1
      JO = JOM (IRUN)
      LTHM = LTHMM (IRUN)
      EL3 = EL3M (IRUN)
      EM3 = EM3M (IRUN)
      Z =ZM (IRUN)
      VEL = VELM (IRUN)
C
```

MAIN PROGRAM (ERG)

```
C     CALCULATES TIME OF ECHO WITH RESPECT TO INPUT PERIODIC
     *ITY.
C
      LTIMH = LTHM/100
      LTIMM = LTHM-LTIMH * 100
      TMINIT = (JO-1) * 1440+LTIMH * 60+LTIMM
      THOUR = TMINIT/60.0
      NEWDAY = THOUR/PERIOD
      T= ( THOUR/PERIOD-FLOAT ( NEWDAY ) ) *6.28318
      SINT = SIN (T)
      COST = COS (T)
C
      DCL = EL3
      DCM = EM3
      DCN = SQRT (1.0-EL3**2-EM3**2)
      S = (2.0*Z-ZMAX-ZMIN)/(ZMAX-ZMIN)
      S =S +0.000001
      SUMP =0
      SUMQ =0
      SUMR =0
      NCOUNT =0
      SUMSA0 =1
      IF (NA0T) 110,110,84
   84 DO8K = 2, NA0T,2
      SUMSA0 = SUMSA0 + S**K
    8 CONTINUE
      SUMSA =1
      DO9K = 2,NA2,2
    9 SUMSA = SUMSA + S**K
      SUMP = SUMP + SUMSA
  110 SUMP = SUMP + SUMSA0
      SUMSB0 = 1
      IF ( NB0T ) 130,130,114
  114 DO11K =2,NB0T,2
      SUMSB0 = SUMSB0 + S**K
   11 CONTINUE
      SUMSB =1
      DO12K = 2,NB2,2
   12 SUMSB = SUMSB + S**K
      SUMQ =SUMQ + SUMSB
  130 SUMQ = SUMQ + SUMSB0
      SUMSC0 = 1
      IF (NC0T) 160,160,135
  135 DO14K =2,NC0T,2
      SUMSC0 = SUMSC0 + S**K
```

```
   14 CONTINUE
      SUMSC=1
      DO15K =2,NC2,2
   15 SUMSC=SUMSC+S**K
      SUMR = SUMR + SUMSC
  160 SUMR = SUMR + SUMSC0
      WF=1.0/( (DCL**2)*SUMP+ (DCM**2)*SUMQ+ (DCN**2)*SUMR )
      SUM3 = SUM3 + WF*VEL**2
      DO20K = 1,NA0E
      NCOUNT = NCOUNT + 1
   20 D ( NCOUNT ) = DCL* ( S**( K-1 ) )
      DO21K = 1,NAE
      NCOUNT = NCOUNT + 1
   21 D (NCOUNT) = DCL*( S**( K-1 ) )*SINT
      DO22K = 1,NAE
      NCOUNT = NCOUNT + 1
   22 D ( NCOUNT ) = DCL*( S**( K-1 ) )*COST
      DO23K = 1,NB0E
      NCOUNT = NCOUNT + 1
   23 D ( NCOUNT ) = DCM*( S**( K-1 ) )
      DO24K = 1,NBE
      NCOUNT = NCOUNT + 1
   24 D ( NCOUNT ) = DCM*( S**( K-1 ) )*SINT
      DO25K = 1,NBE
      NCOUNT = NCOUNT + 1
   25 D ( NCOUNT ) = DCM*( S**( K-1 ) )*COST
      DO26K = 1,NC0E
      NCOUNT = NCOUNT + 1
   26 D ( NCOUNT ) = DCN*( S**( K-1 ) )
      DO27K = 1,NCE
      NCOUNT = NCOUNT + 1
   27 D ( NCOUNT ) = DCN*( S**( K-1 ) )*SINT
      DO28K = 1,NCE
      NCOUNT = NCOUNT + 1
   28 D ( NCOUNT ) = DCN*( S**( K-1 ) )*COST
      DO29J = 1,N
      P ( J ) = P( J ) + WF*VEL*D ( J )
   29 CONTINUE
      DO30J = 1,N
      DO30K = 1,N
      Q ( J,K ) = Q ( J,K ) + WF*D ( J )*D ( K )
   30 CONTINUE
      IF ( IRUN-M ) 60,5894,5894
C
C     INVERSION OF Q,AND FORMATION OF COEFFICIENT COLUMN AC.
```

```
C
5894  DO101J = 1,N
      DO101K = 1,N
      A ( J,K ) = Q ( J,K )
101   CONTINUE
      DO102J = 1,N
      DO102K = NE,N2
      IF ( J-K+N ) 108,107,108
107   A ( J,K ) = 1.0
      GO TO 102
108   A ( J,K ) = 0.
102   CONTINUE
      CALL MATSIN ( N,MISS )
      IF ( MISS ) 1103,1103,1102
1102  CALL PAGE ( RESULT,PERIOD )
      WRITE ( 6,1104 ) N,N
1104  FORMAT(1H0                    /1X53H ***** ERROR IN INPUT DATA
     * HAS RESULTE
     1D IN MATRIX Q ( I3,1H,34H ) BEING UNSUITABLE FOR INVER
     *SION./////
     21X30HPROGRAMME CANNOT BE CONTINUED.////////)
      GO TO 300
1103  CONTINUE
      DO103K = 1,N
      DO103J = 1,N
103   AC ( K ) = AC ( K ) + P ( J , *R ( J,K )
      DO104J = 1,N
      DO104K = 1,N
      SUM1 = SUM1 + AC ( J )*AC ( K )*Q ( J,K )
104   CONTINUE
      DO105J = 1,N
      SUM2 = SUM2 + AC ( J )*P ( J )
105   CONTINUE
      SUM = ( SUM1- ( 2.0*SUM2 ) + SUM3 )/FLOAT ( M-N )
      DO106J = 1,N
      CHECK = R ( J,J ) *SUM
      IF ( CHECK ) 50,50,51
50    CHECK = -CHECK + 0.5
      SIGN = -1.0
      GO TO 106
51    SIGN = + 1.0
106   SIGMA ( J ) = SQRT ( CHECK ) *SIGN
C
C     PRELIMINARY OUTPUT.
C
```

```
      NOGO = NOGO + 1
      IF ( NOGO-1 ) 71,71,72
 71   CALL PAGE ( RESULT,ZERO )
      WRITE ( 6,200 )
 200  FORMAT(1H ////1X48H VARIATION OF UPPER ATMOSPHERE WIND
     *S WITH HEIGH
     1T // 1X51H BASED ON GROVES ANALYSIS, WITH ERROR DETERM
     *INATION////)
      WRITE ( 6,201 ) M,N,MAX,MIN
 201  FORMAT(1H ////1X32H NUMBER OF METEORS PROCESSED  = I5/
     *///1X33H NUM
     1BER OF INPUT PARAMETERS     = I4////
     21X27H HEIGHT RANGE,     MAXIMUM   I5,1X11H  MINIMUM   I
     *5,
     31X15H  KILOMETERS.    /// )
      WRITE ( 6,202 ) NAO,NA
 202  FORMAT ( 1X20H EAST-WEST PROFILE  2I3/1X)
      WRITE ( 6,203 ) NBO,NB
 203  FORMAT ( 1X20H NORTH-SOUTH PROFILE 2I3/1X )
      WRITE ( 6,204 ) NCO,NC
 204  FORMAT ( 1X20H VERTICAL PARAMETERS 2I3 )
   72 CALL PAGE(RESULT,PERIOD)
      WRITE ( 6,206 )
 206  FORMAT ( 1X25H COLUMNS MATRIX AC ( K ) /1X )
      J = 0
      DO205I = 1,N
      J = J + 1
      IF ( J-50 ) 208,208,207
 207  J = 0
      CALL PAGE ( RESULT,PERIOD )
      WRITE ( 6,206 )
 208  WRITE ( 6,209 ) AC ( I ),SIGMA ( I )
 209  FORMAT ( 1X25XF7.2,3XF7.1 )
 205  CONTINUE
      CALL PAGE ( RESULT,PERIOD )
      CALL VARY
      NPASS = NPASS + 1
      WRITE ( 6,299 ) NPASS
  299 FORMAT(1X,12H END OF PASS,I5)
  281 IF(CYCLE-ENDIT) 998,300,300
 300  NHT6 = 6*NHT + 6
      DO301I = 1,NHT6
 301  FINIS ( I ) = 0.0
      WRITE ( 16 )  ( FINIS ( I ),I =1,NHT6 )
      NRECB6 = NRECB6 + 1
```

```
      IF ( IBIT ) 332,332,865
332   END FILE 16
      REWIND 16
      WRITE ( 6,334 ) NRECB6
334   FORMAT ( 1H,I10,2X,26HRECORDS WRITEN IN F2 FILE )
      STOP
  333 WRITE(6,335) IBIT, START, ENDIT, STEP
  335 FORMAT(' SPECTRUM INTERVAL PARAMETERS IN ERROR.'/' IBI
     *T = ',I2,
     1' START =',F8.3,' ENDIT = ',F8.3,' STEP = ',F8.3,' ***
     ********* ')
      STOP
      END
```

SUBROUTINE VARY

```
C     CALCULATES THE AMPLITUDE AND PHASE OF THE PERIODIC COM
     *PONENT,
C     TOGETHER WITH THE MOST PROBABLE ERROR IN EACH.
C     PRINTS THESE OUT AT 2KM INTERVALS OVER THE HEIGHT RANG
     *E SPECIFIED.
C
      DIMENSION A ( 27,54 ),R ( 27,27 )
      DIMENSION AC ( 27 ),AU ( 20 ),PH(20),ERAMP(20),ERPH(20
     *),RESULT(12)
      DIMENSION UO ( 20 ),EO ( 20 ),KHT ( 20 )
      COMMON A,R,NOP,ZMIN,MIN,ZMAX,MAX,SUM,NP,NQ,NR,NAO,NBO,
     *NCO,
     1NA,NB,NC,AC,RESULT,PERIOD
      COMMON KHT,NHT,MY,MO
      COMMON/IOCHK/NRECB6
      NAOE = NAO + 1
      NBOE = NBO + 1
      NCOE = NCO + 1
      KEND = 0
      NSIGN = -1
      IDENT = 1
      WRITE ( 6,597 )
597   FORMAT ( 1X39HEAST-WEST COMPONENTS OF THE MEAN WIND//
     *)
98    WRITE ( 6,87 ) ( KHT ( I ),I = 1,NHT )
   87 FORMAT(1X,8HHEIGHT   ,I5,16I7)
      WRITE ( 6,871 )
871   FORMAT ( 1X )
      IT = 0
      KA=KEND
      DO128KZ = MIN,MAX,2
      IT = IT + 1
      UO ( IT ) = 0.0
      Z = KZ
      S = ( 2.0*Z-ZMAX-ZMIN )/ ( ZMAX-ZMIN )
      S = S + 0.000001
      DO106K = 1,NAOE
      KUA = K + KA
106   UO ( IT ) = UO ( IT ) + AC ( KUA )*S** ( K-1 )
      SIGUO = 0.0
      DO107K = 1,NAOE
      DO107L = 1,NAOE
      KS = K + KA
      LS = L + KA
107   SIGUO = SIGUO + S**( K-1 )*S**( L-1 )*R ( KS,LS )*SUM
```

SUBROUTINE VARY

```
      SIGN=1.0
      IF(SIGUO.LT.0.0) SIGN=-1.0
      FO(IT)=SIGN*SQRT(ABS(SIGUO))
      KEND = KA + NAOE
      SI = 0.0
      CO = 0.0
      SIGCOS = 0.0
      SIGSIN = 0.0
      SIGSC = 0.0
      NUMNA = NA
      NUSIN = NP + NUMNA
      KSTART = KEND
      NAEND = NA + 1
      KEND = KSTART + NAEND
      DO110K = 1,NAEND
      KS = K + KSTART
      SI = SI + AC ( KS )*S** ( K-1 )
      KC = KS + NUSIN
  110 CO = CO + AC ( KC )*S** ( K-1 )
      SINSQJ = SI**2
      COSSQJ = CO**2
      SUMSQJ = SINSQJ + COSSQJ
      AU ( IT ) = SQRT ( SUMSQJ )
      FJ = PERIOD
      IF ( CO ) 114,111,115
  111 IF ( SI ) 113,113,112
  112 PH ( IT ) = FJ/4.0
      GO TO 116
  113 PH ( IT ) = FJ* 0.75
      GO TO 116
  114 PH ( IT ) = FJ*0.5 + ( FJ/6.28318 ) *ATAN ( SI/CO )
      GO TO 116
  115 PH ( IT ) = ( FJ/6.28318 ) *ATAN ( SI/CO )
  116 IF ( PH ( IT ) ) 117,118,118
  117 PH ( IT ) = FJ + PH ( IT )
  118 DO119K = 1,NAEND
      DO119L = 1,NAEND
      KS = K + KSTART
      LS = L + KSTART
      KC = KS + NUSIN
      LC = LS + NUSIN
      SS = S** ( K-1 )*S** ( L-1 )
      SIGSIN = SIGSIN + SS*R ( KS,LS )
      SIGSC = SIGSC + SS*R ( KS,LC )
  119 SIGCOS = SIGCOS + SS*R ( KC,LC )
```

SUBROUTINE VARY

```
      PROD = 2.0*SI*CO*SIGSC
      SIGPH = ( COSSQJ*SIGSIN + SINSQJ*SIGCOS-PROD ) *SUM/SU
     *MSQJ**2
      SIGAMP = ( SINSQJ*SIGSIN + COSSQJ*SIGCOS + PROD )*SUM/
     *SUMSQJ
      IF ( SIGPH ) 10,10,11
10    SIGPH = -SIGPH + 0.5
      SIGN = -1.0
      GO TO 12
11    SIGN = + 1.0
12    FRPH ( IT ) = SQRT ( SIGPH )* ( FJ/6.28318 )*SIGN
      IF ( SIGAMP ) 13,13,14
13    SIGAMP = -SIGAMP + 0.5
      SIGN = -1.0
      GO TO 121
14    SIGN = + 1.0
121   FRAMP ( IT ) = SQRT ( SIGAMP ) *SIGN
128   CONTINUE
      KEND = KEND + NUSIN
      WRITE ( 6,123 ) ( UO ( IT ),IT = 1,NHT )
123   FORMAT ( 1X6HMEAN  16F7.0 )
      WRITE ( 6,1230 ) ( EO ( IT ),IT = 1,NHT )
1230  FORMAT ( 1X6HERROR 16F7.0 )
      WRITE ( 6,871 )
      WRITE ( 6,124 ) ( AU ( IT ),IT = 1,NHT )
124   FORMAT ( 1X6HAMP    16F7.0 )
      WRITE ( 6,1230 ) ( FRAMP ( IT ),IT = 1,NHT )
      WRITE ( 6,871 )
      WRITE ( 6,125 ) ( PH ( IT ),IT = 1,NHT )
125   FORMAT ( 1X5HPHASE16F7.1 )
      WRITE ( 6,1250 ) ( FRPH ( I ),I = 1,NHT )
1250  FORMAT ( 1X5HERROR16F7.1 )
      WRITE ( 6,872 )
872   FORMAT ( 1X/1X )
      WRITE (16) IDENT,MY,MO,PERIOD,KHT(1),NHT,(UO(IT),IT=1,
     *NHT),
     1(EO(IT),IT=1,NHT),(AU(IT),IT=1,NHT),(FRAMP(IT),IT=1,NH
     *T),
     2(PH(IT),IT=1,NHT),(FRPH(IT),IT=1,NHT)
      NRECB6 = NRECB6 +1
      IF( NSIGN ) 129,131,133
129   NAOE = NBOE
      NA = NB
      NSIGN = 0
      IDENT = 2
```

SUBROUTINE VARY

```
      WRITE ( 6,598 )
598   FORMAT ( 1X39HNORTH-SOUTH COMPONENTS OF THE MEAN WIND/
     */ )
      GO TO 98
131   NAOE = NCOE
      NA = NC
      NSIGN = 1
      IDENT = 3
      WRITE(6,599)
599   FORMAT ( 1X39HVERTICAL COMPONENTS OF THE WIND
     */)
      GO TO 98
133   RETURN
      END
```

```
      SUBROUTINE MATSIN ( N,MISS )
C
C     INVERSION OF MATRIX OF ORDER N, UP TO 27X27.
C
C     PROCEEDS VIA A METHOD OF GAUSSIAN  ELIMINATION,DESTROY
     *ING
C     THE AUGMENTED MATRIX A IN THE PROCESS.
C
      DIMENSION A ( 27,54 ),X ( 27.27 )
      COMMONA,X
      MISS = -1
      MM = 2*N
      DO 15 I = 2,N
70    II = I-1
7     DO 15 J = 1,II
8     IF ( A ( I,J ) ) 9,15,9
9     IF ( ABS ( A ( J,J ) ) -ABS ( A ( I,J ))) 11,10,10
10    R = A ( I,J )/A ( J,J )
      GO TO 130
11    R = A ( J,J ) /A ( I,J )
      DO 12 K = 1,MM
      B = A ( J,K )
      A ( J,K ) = A ( I,K )
12    A ( I,K ) = B
130   JJ = J + 1
      DO14 K = JJ,MM
14    A ( I,K ) = A ( I,K )-R*A ( J,K )
15    CONTINUE
      IF ( ABS ( A ( N,N ) )-1.0E-10 ) 16,16,17
16    MISS = 1
      GO TO 29
17    DO28J = 1,N
      KK = N + J
      X ( N,J ) = A ( N,KK ) /A ( N,N )
      DO28I = 2,N
      JJ = N-I + 1
      B = 0.
      II = N-I + 2
      DO 25 K = II,N
25    B = B + A ( JJ,K )*X ( K,J )
      IF ( ABS ( A ( JJ,JJ ) )-1.0E-10 ) 16,16,28
28    X ( JJ,J ) = ( A ( JJ,KK )-B ) /A ( JJ,JJ )
29    RETURN
      END
```

```
      SUBROUTINE PAGE (RESULT,PERIOD)
C
C     TURNS PAGE, IDENTIFIES RUN AND DATA, AND NUMBERS PAGES
     *.
C
       INTEGER STRTDA,ENDDAY,DATE
      DIMENSION RESULT(12),SOURCE(2),DATE(3),A(27,54),B(27,2
     *7)
      COMMON/INTRVL/STRTDA,ENDDAY,IMY,IMONTH,IJO,JMY,JMONTH,
     *JJO,JUMP,
     1SOURCE,DATE,FREQ
      COMMON A,B,NOP
C
      NOP=NOP+1
      IF(PERIOD)1,1,3
    1 WRITE(6,2)RESULT,DATE,SOURCE,NOP
    2 FORMAT(1H1/,1X,12A6,5X,6HRUN ON ,A4,I3,4H, 19,I2,6X,2A
     *4,4HPAGE,
     1I5/1X,18H SPECTRUM ANALYSIS/1X)
      RETURN
    3 IF(JUMP.EQ.1) GO TO 5
      WRITE(6,4)RESULT,PERIOD,SOURCE,NOP,IMONTH,IJO,IMY,JMON
     *TH,JJO,JMY,
     1FREQ
    4 FORMAT(1H1/1X,12A6,1X,6HPERIOD,F8.2,6H HOURS,5X,2A4,2X
     *,4HPAGE,I5//
     11X,A4,I3,4H, 19,I2,3H TO,A4,I3,4H, 19,I2,50X,9HFREQUEN
     *CY,F8.4,
     212H CYCLES/DAY.///)
      RETURN
    5 WRITE(6,4)RESULT,PERIOD,SOURCE,NOP
      WRITE(6,6) STRTDA,ENDDAY,FREQ
    6 FORMAT(1X,17H ALL DATA IN FILE,6X,I6,I8,44X,9HFREQUENC
     *Y,F8.4,
     112H CYCLES/DAY.///)
      JUMP=0
      RETURN
      END
```

```
      SUBROUTINE MONTH(NMONTH,NMO)
C
C     REPLACES NUMERICAL MONTH WORD WITH APPROPRIARE HOLERIT
     *H WORD
C     TRANSFERS * IF NMO.LT.1.OR.GT.12
C
      IF(NMO.LT.1.OR.NMO.GT.12) GO TO 13
      GO TO (1,2,3,4,5,6,7,8,9,10,11,12),NMO
    1 NMONTH=4H JAN
      GO TO 14
    2 NMONTH=4H FEB
      GO TO 14
    3 NMONTH=4H MAR
      GO TO 14
    4 NMONTH=4H APL
      GO TO 14
    5 NMONTH=4H MAY
      GO TO 14
    6 NMONTH=4H JUN
      GO TO 14
    7 NMONTH=4H JLY
      GO TO 14
    8 NMONTH=4H AUG
      GO TO 14
    9 NMONTH=4H SEP
      GO TO 14
   10 NMONTH=4H OCT
      GO TO 14
   11 NMONTH=4H NOV
      GO TO 14
   12 NMONTH=4H DEC
      GO TO 14
   13 NMONTH=4H *
   14 RETURN
      END
```

APPENDIX II.

The transmit/receive/echo position geometry is presented as used in program DECØDE rather than program METEØR. The analytic treatment in DECØDE is exact, whereas in METEØR the T/R system midpoint is used as the intersection of the meteor trail normal with the TR axis. This results in a maximum "error" or discrepancy in altitude of 700 meters, between METEØR and DECØDE echo altitudes, together with a discrepancy in the 3rd figure of the direction cosines of echo arrival.

APPENDIX II A Echo Range Geometry

Measured Parameters

ϕ Phase difference in radians between upper and lower sideband echoes as received at the receiving site R.

ℓ_1, m_1, n_1, the direction cosines of the echo arrival angle at R

Also known

d the transmitter/receiver separation

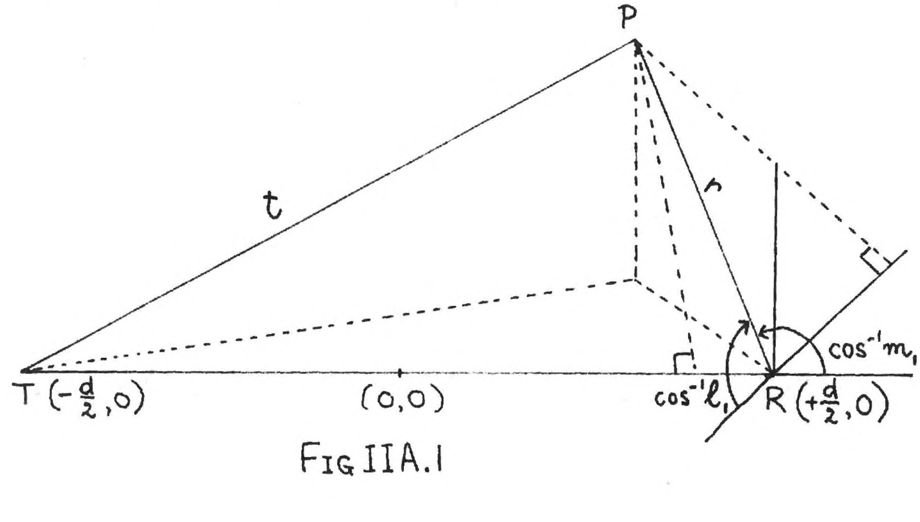


FIG IIA.1

Referring to figure IIA.1

$$t + r = \frac{1}{2\pi} \frac{c}{\Delta f} \phi + d$$

where c is the velocity of light, and Δf is the difference in frequency between the transmitted sidebands.

The locus of reflection points for an echo with any measured ϕ lies on an ellipse; the plane of this elipse contains, t, r and d.

In this plane, the angle between the echo arrival vector at R and the line TR produced is θ. The equation of this ellipse is

$$\frac{x^2}{a^2} + \frac{y^2}{b^2} = 1$$

where (x, y) now define the ellipse plane. The ellipse constants are related to the measured variables thus - $t + r = 2a$ ie. $a = \frac{t + r}{2}$

$$b^2 = a^2 - \left(\frac{d}{2}\right)^2$$

Since we wish to determine r, the range of the reflection point from the receiving site R, it is convenient to express the equation in terms of r, θ, centered on R (i.e. in polar form)

$$\sin\theta = \frac{y}{r} \qquad y = r \sin\theta$$

$$\cos\theta = \frac{x - \frac{d}{2}}{r} \qquad x = r\cos\theta + \frac{d}{2}$$

Substituting for (x, y) in the ellipse equation

$$\left(\frac{r\cos\theta + \frac{d}{2}}{a}\right)^2 + \left(\frac{r\sin\theta}{2}\right)^2 = 1$$

$$\frac{r^2\cos^2\theta + rd\cos\theta + \frac{d^2}{4}}{a^2} + \frac{r^2\sin^2\theta}{b^2} = 1$$

$$\left(\frac{\cos^2\theta}{a^2} + \frac{\sin^2\theta}{b^2}\right) r^2 + \frac{d\cos\theta}{a^2} r + \left(\frac{d^2}{4a^2} - 1\right) = 0$$

$$r = \frac{-\frac{d\cos\theta}{a^2} \pm \sqrt{\left[\frac{d^2\cos^2\theta}{a^4} - 4\left(\frac{\cos^2\theta}{a^2} + \frac{\sin^2\theta}{b^2}\right)\left(\frac{d^2}{4a^2} - 1\right)\right]}}{2\left(\frac{\cos^2\theta}{a^2} + \frac{\sin^2\theta}{b^2}\right)}$$

Expansion and simplification of the square root results in

$$r = \frac{-\frac{d\cos\theta}{a^2} \pm \frac{2}{a}}{2\left(\frac{\cos^2\theta}{a^2} + \frac{\sin^2\theta}{b^2}\right)} \quad \frac{\times \frac{a^2}{2}}{\times \frac{a^2}{2}}$$

which yields

$$r = \frac{-\frac{d}{2}\cos\theta \pm a}{\cos^2\theta + \frac{a^2}{b^2}\sin^2\theta}$$

a, the semi major axis, is always greater than $\frac{d}{2}$, the distance from the center of the elipse to the focus, and therefore choice of the negative square root will result in a negative r, which is an impossible solution.

$$r = \frac{a - \frac{d}{2}\cos\theta}{\cos^2\theta + \frac{a^2}{b^2}\sin^2\theta}$$

Substituting for a and b in terms of the measured variables

$$r = \frac{\frac{1}{4\pi}\frac{c}{\Delta f}\phi + \frac{d}{2} - \frac{d}{2}m_1}{m_1^{\,2} + \dfrac{(\frac{1}{4\pi}\ \frac{c}{\Delta f}\phi + \frac{d}{2})^2}{(\frac{1}{4\pi}\frac{c}{\Delta f}\ \phi + \frac{d}{2})^2 - (\frac{d}{2})^2} \qquad (1 - m_1^{\,2})}$$

which could perhaps be simplified, but has been programmed as such.

[In DECØDE, S=r]

APPENDIX II B Translation Geometry

In the plane of the ellipse defined in Appendix IIA, the coordinates of the reflection point are

$$x = \frac{d}{2} + m_1 r$$

$$y = \sqrt{1 - m_1^2}\; r$$

The doppler beat which results when the groundwave appropriate to a given transmitted sideband beats with the reflected skywave appropriate to that sideband is a measure of the change in skywave path length with time, normal to the reflecting trail, since the reflection is specular. Thus the direction cosines to be associated with the measured "line of sight" velocity are not those of the received echo, but rather those of the normal to the trail at the point where the trail touches the constant phase path ellipse. The origin for specification of these direction cosines is most appropriately chosen as the intersection of the above specified trail normal with the x axis.

The normal to the ellipse

$$\frac{x^2}{a^2} + \frac{y^2}{b^2} = 1$$

can be parameterized as

$$n = \frac{2x}{a^2}\, i + \frac{2y}{b^2}\, j$$

The slope of the line through the intersection of the normal with the x axis (x_o, 0) and the reflection point (X, Y) i.e. the trail normal is given by

$$\frac{Y}{X - X_o} = \frac{\frac{2Y}{b^2}}{\frac{2X}{a^2}}$$

i.e.

$$x - x_o = \frac{b^2}{a^2} x$$

The echo range appropriate to this newly defined origin is

$$R_o = \left[\frac{b^4}{a^4} X^2 + Y^2\right]^{1/2}$$

If ℓ_1, m_1, n_1 are the direction cosines of r in the x, y, z system centered on R, and ℓ_2, m_2, n_2 are the direction cosines of R_o in the x' y' z' system centered on the point $\frac{d}{2} - x_o$ from R (see Figure IIB.1), where the y and y' axes are coincident on the transmit/receive system line (TR in Figure IIA.1), then

$$\ell_2 = \frac{X}{R_o} = \frac{r\,\ell_1}{R_o}$$

$$m_2 = \frac{Y + \frac{d}{2} - x_o}{R_o} = \frac{r\,m_1 + \frac{d}{2} - x_o}{R_o}$$

$$n_2 = \left[1 - \ell_2^{\,2} - m_2^{\,2}\right]^{1/2}$$

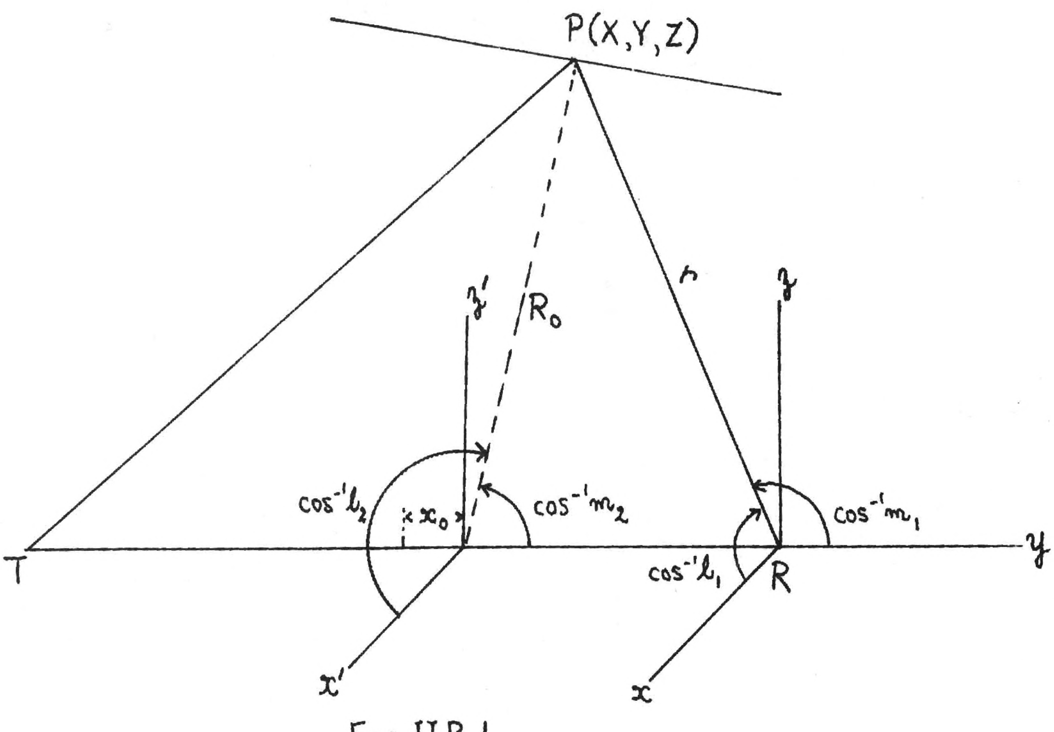


FIG IIB.1

APPENDIX IIC Rotation Geometry

Given ℓ_2, m_2, n_2

which are appropriate to the axes defined by the TR system line, with origin centered on the trail normal intersection,

find ℓ_3, m_3, n_3

appropraite to a NS/EW system of axes

This is a simple rotation of axes, with the rotation angle

$$\theta = \text{compass azimuth of R from T (radians)} - \pi$$

Thus

$$\ell_3 = \ell_2 \cos\theta + m_2 \sin\theta$$

$$m_3 = m_2 \cos\theta - \ell_2 \sin\theta$$

$$n_3 = n_2$$

APPENDIX III

LISTINGS OF INPUT DATA CARDS
AND SAMPLE OUTPUTS

LØCATE

METEØR

DECØDE

LØADIT

GRØVES

ERG

PROGRAM LØCATE - ALL DATA INTERNAL TO PROGRAM

PROGRAM METEØR

HEADER CARD

```
 TEST RUN OF NOISY DATA      CT      DECEMBER  6,1974                         ATLANTIS
```

1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32 33 34 35 36 37 38 39 40 41 42 43 44 45 46 47 48 49 50 51 52 53 54 55 56 57 58 59 60 61 62 63 64 65 66 67 68 69 70 71 72 73 74 75 76 77 78 79 80

OPTIONS CARD

```
1100110011        1000        5.0        .01
```

1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32 33 34 35 36 37 38 39 40 41 42 43 44 45 46 47 48 49 50 51 52 53 54 55 56 57 58 59 60 61 62 63 64 65 66 67 68 69 70 71 72 73 74 75 76 77 78 79 80

NAME OF DECØDE INPUT FILE TO BE GENERATED

```
 NOISETEST
```

1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32 33 34 35 36 37 38 39 40 41 42 43 44 45 46 47 48 49 50 51 52 53 54 55 56 57 58 59 60 61 62 63 64 65 66 67 68 69 70 71 72 73 74 75 76 77 78 79 80

NAME OF GRØVES/ERG INPUT FILE TO BE GENERATED

```
 NONE
```

1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32 33 34 35 36 37 38 39 40 41 42 43 44 45 46 47 48 49 50 51 52 53 54 55 56 57 58 59 60 61 62 63 64 65 66 67 68 69 70 71 72 73 74 75 76 77 78 79 80

@FIN

```
   RUNID * 4G11          FILE NAME * PR00004G11          PART NUMBER *  00      DATE * 061174        DEVICE NAME  *   PR1

12345678901234567890123456789012345678901234567890123456789012345678901234567890123456789012345678901234567890**SEQ NO. 06
@RUN METDEC,111A0116,ROPER-R-0,20,200                                                      4G11  CR1
@DELETE,C DATOUT,DECOUT,DUMMY
FURPUR 0025-06/11-15:46
@ASG,A METEOR,F2
@ASG,A DECODE,F2
@ASG,CP DUMMY,F2
@USE 4,DUMMY
@ASG,CP DATOUT,F2
@USE 16,DATOUT
@XQT METEOR.XQT
 OUTPUT OPTIONS SPECIFIED ARE

 1.    2000 RECORDS TO BE WRITTEN IN FILE    DATOUT    FOR INPUT TO 'DECODE'

 2.          ECHO DATA TO BE LISTED IN 'GROVES/ERG' INPUT FORMAT

 8.          HEIGHT RANGE RESTRICTED TO 77 TO 104 KM

 9.          DOPPLERS EQUAL:  MWAVE1 = MWAVE2

 10.         RANGES EQUAL:     MRNGE1 = MRNGE2

  7001.84  4  1   40  .616 -.248  .418 -.491 894  6 1 -25  29 -25.  3  3ATLANTIS *  2814  2814  1080   697  2646    22  1396  1396
  7002.84  4  1   46  .393  .059  .427 -.078 878  6 1 -60  11 -26.  3  3ATLANTIS *  2622  2622  1591  2468   848  1720  1063  1063
  7003.84  4  1   50 -.404 -.651 -.700 -.211 942  6 1 -25  -7  19.  3  3ATLANTIS *  3643  3643  2172  1272  2053   682  2160  2160
  7004.84  4  1   55 -.503 -.379 -.585  .092 989  6 1 -23   4  14.  3  3ATLANTIS *  5053  5053  2513  3139  1129  3343  2649  2649
  7005.84  4  1   58  .366 -.267  .232 -.349 895  6 1 -23  34 -17.  3  3ATLANTIS *  4025  4025  2472  1073  3689   362  1655  1655
  7006.84  4  1  100  .465 -.356  .247 -.504 952  6 1 -14  28 -17.  3  3ATLANTIS *  3956  3956  2038  1407  3186  3501  1929  1929
  7007.84  4  1  103  .621  .277  .703 -.069 937  6 1 -44   4 -31.  3  3ATLANTIS *  2226  2226   843  1609  1328  2058  1263  1263
  7008.84  4  1  108  .236  .133  .352  .085 833  6 1 -60 -15 -22.  3  3ATLANTIS *  3076  3076  2350  2667  1281  2661  1130  1130
  7009.84  4  1  110 -.571 -.288 -.577  .210 953  6 1 -16   6  19.  3  3ATLANTIS *  6656  6656  2855  4740   731  3117  3423  3423
  7010.84  4  1  112  .676  .087  .598 -.197 869  6 1 -43  14 -29.  3  3ATLANTIS *  2420  2420   954  2211   867  1449  1143  1143
  7011.84  4  1  115 -.168 -.056 -.079  .173 916  6 1  22 -48 -19.  3  3ATLANTIS *  6923  6923  1163   389  1243  5091  2676  2676
  7012.84  4  1  117 -.235  .270  .058  .447 917  6 1  -4 -33 -15.  3  3ATLANTIS *  4677  4677  1100  3413  2749  1593  2010  2010
  7013.84  4  1  119  .537 -.043  .482 -.251 839  6 1 -45  23 -27.  3  3ATLANTIS *  2535  2535  1173   108   497  1029  1057  1057
  7014.84  4  1  123 -.545 -.016 -.372  .4071001  6 1 -17  19  14.  3  3ATLANTIS *  4980  4980  2268  4902  3834    27  2545  2545
  7015.84  4  1  131 -.709 -.028 -.522  .4831010  6 2 -28  26  27.  3  3ATLANTIS *  2517  2517   732  2448  1975  2375  1562  1562
  7016.84  4  1  133 -.035  .638  .397  .574 943  6 2 -17 -25 -21.  3  3ATLANTIS *  3235  3235   114  1172   152  2859  1821  1821
  7017.84  4  1  134  .692 -.209  .488 -.518 992  6 2 -35  37 -36.  3  3ATLANTIS *  1928  1928   594   403  1907    73  1176  1176
  7018.84  4  1  143  .438 -.300  .250 -.418 920  6 2 -14  24 -13.  3  3ATLANTIS *  5166  5166  2901  1551  4519    26  2287  2287
  7019.84  4  1  145  .418 -.439  .156 -.521 798  6 2 -15  51 -29.  3  3ATLANTIS *  2370  2370  1380  1040  1663  1834   932   932
  7020.84  4  1  149 -.483 -.423 -.601  .0401007  6 2 -26   2  16.  3  3ATLANTIS *  4326  4326  2238  2496  1206  3241  2337  2337
  7021.84  4  1  154  .233  .409  .489  .282 815  6 2 -33 -19 -21.  3  3ATLANTIS *  3220  3220  2472  1905  2449  1123  1318  1318
  7022.84  4  1  201  .221  .391  .468  .270 876  6 2 -36 -21 -22.  3  3ATLANTIS *  3076  3076  2397  1873  2274   998  1339  1339
  7023.84  4  1  206 -.744  .260 -.364  .714 868  6 2   7 -13 -11.  3  3ATLANTIS *  6020  6020  4476  4459  3458  3468  3754  3754
  7024.84  4  1  212  .802  .171  .781 -.273 863  6 2 -18   6 -16.  3  3ATLANTIS *  4381  4381   868  3634  2029  2837  2904  2904
  7025.84  4  1  215 -.217  .217  .050  .408 842  6 2  -5 -37 -15.  3  3ATLANTIS *  4466  4466   969  3497  2327  1064  1701  1701
  7026.84  4  1  217  .675 -.229  .478 -.509 823  6 2 -24  25 -24.  3  3ATLANTIS *  2894  2894   938   659  2781    35  1401  1401
  7027.84  4  1  218  .562 -.279  .367 -.472 812  6 2 -29  37 -29.  3  3ATLANTIS *  2472  2472  1084   689  2229  2426  1044  1044
  7028.84  4  1  220  .531  .075  .524 -.121 771  6 2 -76  17 -42.  3  3ATLANTIS *  1656  1656   827  1532   569  1044   623   623
  7029.84  4  1  222 -.531  .139 -.231  .502 914  6 2  13 -29 -13.  3  3ATLANTIS *  3933  3933  1970  3389  1664   956  1818  1818
  7030.84  4  1  225  .458  .184  .534 -.033 961  6 2 -44   3 -23.  3  3ATLANTIS *  2945  2945  1597  2404  1413  2482  1419  1419
  7031.84  4  1  236 -.136 -.359 -.219 -.105 828  6 3  43  21 -12.  3  3ATLANTIS *  5968  5968   630  2144  4780  1037  2079  2079
  7032.84  4  1  238  .535 -.670  .065 -.8401012  6 3  -4  54 -46.  3  3ATLANTIS *  1505  1505   700  1007   622   468  1231  1231
  7033.84  4  1  240 -.787  .332 -.361  .784 845  6 3   7 -14 -13.  3  3ATLANTIS *  5128  5128  4034  3423  3408  3712  3710  3710
  7034.84  4  1  251  .390 -.518  .059 -.5971029  6 3  -8  84 -51.  3  3ATLANTIS *  1365  1365   833   707   822   885   752   752
```

8973.84	4	6	709	-.491	-.615	-.749	-.128	966	6	7	46	8	-35.	3	3ATLANTIS	*	1955	1955	960	1203	941	1797	1254	1254
8974.84	4	6	714	-.434	-.463	-.621	.028	794	6	7	-46	2	20.	3	3ATLANTIS	*	2420	2420	1249	1299	796	1982	1021	1021
8975.84	4	6	715	.780	.219	.791	-.219	857	6	7	-23	6	-10.	3	3ATLANTIS	*	3568	3568	784	2785	1870	2654	2304	2304
8976.84	4	6	721	-.476	.019	-.285	.402	927	6	7	20	-28	-17.	3	3ATLANTIS	*	4145	4145	1972	4067	1134	88	1858	1858
8977.84	4	6	725	-.081	.386	.243	.443	856	6	7	-15	-28	-16.	3	3ATLANTIS	*	4273	4273	346	2624	3130	1992	1761	1761
8978.84	4	6	730	.637	-.388	.340	-.641	952	6	8	8	-15	13.	3	3ATLANTIS	*	5451	5451	3474	3335	1292	1352	3244	3244
8979.84	4	6	732	.263	.287	.444	.168	933	6	8	28	10	14.	3	3ATLANTIS	*	4945	4945	1300	1421	1933	4345	2201	2201
8980.84	4	6	738	.231	.130	.345	.084	840	6	8	-54	-13	-20.	3	3ATLANTIS	*	3532	3532	2718	3075	1455	3043	1304	1304
8981.84	4	6	740	.473	-.052	.422	-.225	921	6	8	19	-10	10.	3	3ATLANTIS	*	6854	6854	3241	6499	5586	3957	3019	3019
8982.84	4	6	743	.742	.316	.809	-.128	959	6	8	44	-7	36.	3	3ATLANTIS	*	1907	1907	1415	602	678	131	1383	1383
8983.84	4	6	747	.517	.187	.580	-.067	945	6	8	40	-5	23.	3	3ATLANTIS	*	2945	2945	1523	551	1520	533	1455	1455
8984.84	4	6	753	-.407	.158	-.146	.461	958	6	8	7	-23	-12.	3	3ATLANTIS	*	5968	5968	2428	5028	2667	1368	2756	2756
8985.84	4	6	805	.550	.211	.615	-.075	986	6	8	37	-4	23.	3	3ATLANTIS	*	3010	3010	1655	636	1463	467	1617	1617
8986.84	4	6	806	.054	.115	.209	.188	791	6	8	-90	-81	-34.	3	3ATLANTIS	*	2036	2036	1926	1802	802	1882	680	680
8987.84	4	6	812	-.458	.640	.164	.814	1012	6	8	-1	-19	-15.	3	3ATLANTIS	*	4495	4495	2101	1619	225	467	3425	3425
8988.84	4	6	814	.526	-.141	.465	-.366	818	6	8	-17	14	-13.	3	3ATLANTIS	*	5325	5325	2203	752	391	1116	2257	2257
8989.84	4	6	817	.431	-.019	.454	-.191	829	6	8	-30	13	-16.	3	3ATLANTIS	*	4273	4273	2219	82	965	2033	1687	1687
8990.84	4	6	822	-.022	-.641	-.362	-.436	918	6	8	28	33	-25.	3	3ATLANTIS	*	2814	2814	61	1804	1262	1798	1321	1321
8991.84	4	6	826	.237	.419	.499	.200	778	6	8	-112	-65	-75.	3	3ATLANTIS	*	924	924	705	537	715	337	363	363
8992.84	4	6	830	.208	-.568	-.107	-.508	828	6	9	-6	-29	15.	3	3ATLANTIS	*	4524	4524	939	1955	2080	1572	1816	1816
8993.84	4	6	831	-.341	-.517	-.535	-.100	770	6	9	-107	-20	50.	3	3ATLANTIS	*	1167	1167	769	564	462	1149	440	440
8994.84	4	5	834	-.029	-.303	-.130	-.122	976	6	9	49	46	-12.	3	3ATLANTIS	*	5721	5721	163	1732	4986	1340	2370	2370
8995.84	4	6	835	.382	-.589	.018	-.648	827	6	9	1	-25	16.	3	3ATLANTIS	*	4273	4273	1631	1756	2078	2016	1948	1948
8996.84	4	6	845	-.310	.507	.131	.648	837	6	9	-6	-30	-20.	3	3ATLANTIS	*	3410	3410	1056	1682	3013	2701	1600	1600
8997.84	4	6	850	-.415	-.362	-.500	.053	1033	6	9	28	-3	-14.	3	3ATLANTIS	*	4807	4807	1992	1742	3831	1552	2449	2449
8998.84	4	6	855	.172	.643	.553	.460	922	6	9	34	29	32.	3	3ATLANTIS	*	2150	2150	370	1383	2034	453	1221	1221
8999.84	4	6	903	-.303	-.454	-.465	-.084	927	6	9	62	11	-30.	3	3ATLANTIS	*	2323	2323	703	1055	1585	247	1025	1025
0.84	4	6	905	.344	-.672	-.081	-.711	927	6	9	3	29	-21.	3	3ATLANTIS	*	3312	3312	2173	2226	1357	1330	1880	1880

```
OUTPUT FILE INVENTORY

  2000 RECORDS FOR INPUT TO 'DECODE', WRITTEN IN FILE    DATOUT

     0 RECORDS FOR INPUT TO 'GROVES' OR 'ERG' IN FILE    DUMMY

     0 CARDS PUNCHED FOR INPUT TO 'LOADIT'

NORMAL EXIT.  EXECUTION TIME:        57848 MLSEC.
@USE 17,DATOUT
@ASG,CP DECOUT,F2
@USE 16,DECOUT
@XQT DECODE.XQT
 1984
```

PROGRAM DECØDE

YEAR DATA RECORDED

1975

HEADER CARD

CHECKOUT OF DIGITAL LOGIC AT FIELDSITE %10%   GEORGIA TECH FACILITY ATLANTA

DATA INPUT FILENAME

ROC8

OUTPUT FILENAME (FOR SUBSEQUENT PROCESSING BY GRØVES OR ERG)

MAY1975

[CONTINUED ON NEXT PAGE]

DECØDE INPUT DATA (CONTINUED)

OPTIONS CARD

```
0111100         90000 0.12 0.12
```

1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32 33 34 35 36 37 38 39 40 41 42 43 44 45 46 47 48 49 50 51 52 53 54 55 56 57 58 59 60 61 62 63 64 65 66 67 68 69 70 71 72 73 74 75 76 77 78 79 80

CLOCK RATE CARD

```
15000.
```

1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32 33 34 35 36 37 38 39 40 41 42 43 44 45 46 47 48 49 50 51 52 53 54 55 56 57 58 59 60 61 62 63 64 65 66 67 68 69 70 71 72 73 74 75 76 77 78 79 80

@FIN

[REQUIRES FIELDSITE DATA OUTPUT TAPE ON UNIT 17]

INPUT FILE IS DATOUT OUTPUT FILE IS DECOUT
LINK 1110000000
START NUMBER 7000.
PHASES MATCHED TO X = .10, C = .10
DIGITAL LOGIC PHASE LAGS 0 0 0
NBIT 0
69231.

TRANSMITTER LATITUDE 33. 46. 19. LONGITUDE-84. 23. 46.
RECEIVER LATITUDE 33. 57. 56. LONGITUDE-84. 13. 7.
T/R SEPARATION 27.037KM
MIDPOINT COORDINATES -8.203 -10.745
RECEIVING SITE ANTENNA CORRECTIONS, L .0000 M .0000
AXIS ROTATION COS .7949 SIN .6068
LOCAL MEAN SOLAR TIME CORRECTION -37 MINUTES.

7001.84	4	1	3	.616	-.248	.418	-.491	894	224	-25	29	-25.	0	OATLANTIS	2814	2814	1080	697	2646	22	1396	1396
7002.84	4	1	9	.393	.059	.426	-.078	878	224	-60	11	-26.	0	OATLANTIS	2622	2622	1591	2468	848	1720	1063	1063
7003.84	4	1	13	-.404	-.651	-.700	-.209	942	224	-25	-7	10.	0	OATLANTIS	3643	3643	2172	1272	2053	682	2160	2160
7004.84	4	1	18	-.503	-.379	-.585	.093	989	324	-23	4	14.	0	OATLANTIS	5053	5053	2513	3139	1129	3343	2649	2649
7005.84	4	1	21	.386	-.267	.233	-.349	895	224	-23	34	-17.	0	OATLANTIS	4025	4025	2472	1073	3689	362	1655	1655
7006.84	4	1	23	.485	-.356	.248	-.503	952	224	-14	28	-19.	0	OATLANTIS	3956	3956	2038	1407	3186	3501	1929	1929
7007.84	4	1	26	.621	.277	.702	-.070	937	224	-44	4	-31.	0	OATLANTIS	2226	2226	843	1609	1328	2058	1263	1263
7008.84	4	1	31	.236	.133	.351	.083	833	1 1	-61	-14	-23.	0	OATLANTIS	3076	3076	2350	2667	1281	2661	1130	1130
7009.84	4	1	33	-.571	-.288	-.577	.211	953	2 1	-16	6	10.	0	OATLANTIS	6656	6656	2855	4740	731	3117	3423	3423
7010.84	4	1	35	.606	.086	.598	-.197	869	2 1	-43	14	-20.	0	OATLANTIS	2420	2420	954	2211	867	1449	1143	1143
7011.84	4	1	38	-.168	-.056	-.079	.172	916	2 1	22	-48	-10.	0	OATLANTIS	6923	6923	1163	389	1243	5091	2676	2676
7012.84	4	1	40	-.235	.270	.057	.446	917	2 1	-4	-33	-15.	0	OATLANTIS	4677	4677	1100	3413	2749	1593	2010	2010
7013.84	4	1	42	.537	-.043	.482	-.251	839	1 1	-45	23	-27.	0	OATLANTIS	2535	2535	1173	108	497	1029	1057	1057
7014.84	4	1	46	-.545	-.016	-.372	.406	1000	3 1	-17	19	14.	0	OATLANTIS	4980	4980	2268	4902	3834	27	2545	2545
7015.84	4	1	54	-.709	-.027	-.522	.483	1009	3 1	-28	26	20.	0	OATLANTIS	2517	2517	732	2448	1975	2375	1562	1562
7016.84	4	1	56	-.035	.638	.396	.573	942	2 1	-17	-25	-21.	0	OATLANTIS	3235	3235	114	1172	152	2859	1821	1821
7017.84	4	1	57	.692	-.209	.489	-.518	992	3 1	-35	37	-36.	0	OATLANTIS	1928	1928	594	403	1907	73	1176	1176
7018.84	4	1	106	.438	-.300	.250	-.417	920	2 1	-14	24	-13.	0	OATLANTIS	5166	5166	2901	1551	4519	26	2287	2287
7019.84	4	1	108	.418	-.439	.157	-.520	797	1 1	-16	51	-20.	0	OATLANTIS	2370	2370	1380	1040	1663	1834	932	932
7020.84	4	1	112	-.483	-.423	-.601	.041	1007	3 1	-27	2	16.	0	OATLANTIS	4326	4326	2238	2496	1206	3241	2337	2337
7021.84	4	1	117	.232	.408	.487	.280	815	1 1	-33	-19	-22.	0	OATLANTIS	3220	3220	2472	1905	2449	1123	1318	1318
7022.84	4	1	124	.221	.391	.467	.269	876	2 1	-36	-21	-23.	0	OATLANTIS	3076	3076	2397	1873	2274	998	1339	1339
7023.84	4	1	129	-.744	.259	-.364	.713	867	2 1	7	-13	-12.	0	OATLANTIS	6020	6020	4476	4459	3458	3468	3754	3754
7024.84	4	1	135	.302	.171	.781	-.274	863	2 2	-18	6	-16.	0	OATLANTIS	4381	4381	668	3634	2029	2837	2904	2904
7025.84	4	1	138	-.217	.217	.049	.407	842	1 2	-5	-38	-16.	0	OATLANTIS	4466	4466	969	3497	2327	1064	1701	1701
7026.84	4	1	140	.675	-.229	.478	-.508	823	1 2	-24	25	-24.	0	OATLANTIS	2884	2884	938	659	2781	35	1401	1401
7027.84	4	1	141	.561	-.279	.367	-.471	812	1 2	-29	37	-28.	0	OATLANTIS	2472	2472	1084	689	2229	2426	1044	1044
7028.84	4	1	143	.501	.075	.523	-.122	771	1 2	-76	18	-42.	0	OATLANTIS	1656	1656	827	1532	569	1044	623	623
7029.84	4	1	145	-.501	.136	-.232	.502	913	2 2	13	-29	-13.	0	OATLANTIS	3933	3933	1970	3389	1664	956	1818	1818
7030.84	4	1	148	.458	.184	.534	-.034	961	3 2	-44	3	-24.	0	OATLANTIS	2945	2945	1597	2404	1413	2482	1419	1419

8991.64	4	6	749	.237	.419	.498	.288	778	1	8	-113	-65	-75.	0	OATLANTIS	924	924	705	537	715	337	363	363
8992.64	4	6	753	.208	-.568	-.106	-.507	828	1	8	-6	-29	15.	0	OATLANTIS	4524	4524	939	1955	2080	1572	1816	1816
8993.64	4	6	754	-.341	-.517	-.534	-.098	769	1	8	-107	-20	59.	0	OATLANTIS	1167	1167	769	564	462	1149	440	440
8994.64	4	6	757	-.028	-.303	-.130	-.121	976	3	8	50	47	-12.	0	OATLANTIS	5721	5721	163	1732	4986	1340	2370	2370
8995.64	4	6	758	.382	-.589	.020	-.647	827	1	8	1	-25	16.	0	OATLANTIS	4273	4273	1631	1756	2078	2016	1948	1948
8996.64	4	6	808	-.310	.507	.130	.647	837	1	8	-6	-30	-20.	0	OATLANTIS	3410	3410	1056	1682	3013	2701	1600	1600
8997.64	4	6	813	-.414	-.362	-.499	.053	1033	3	8	29	-3	-14.	0	OATLANTIS	4807	4807	1992	1742	3831	1552	2449	2449
8998.64	4	6	818	.172	.643	.553	.460	922	2	8	34	29	37.	0	OATLANTIS	2150	2150	370	1383	2034	453	1221	1221
8999.64	4	6	826	-.353	-.454	-.464	-.083	927	2	8	62	11	-39.	0	OATLANTIS	2323	2323	703	1055	1585	247	1025	1025
9000.64	4	6	828	.344	-.672	-.080	-.710	927	2	8	3	29	-21.	0	OATLANTIS	3312	3312	2173	2226	1357	1330	1880	1880

***** LAST 5 WORDS READ FROM UNIT 17 WERE EOFEOF EOFEOF EOFEOF EOFEOF EOFEOF *****

INPUT/OUTPUT FILE STATISTICS

2000 ECHOES READ FROM INPUT TAPE DATOUT

0 OF THESE BEING INCONSISTENT

2000 RECORDS IN FASTRAND FILE DECOUT

0 REJECTS

MISS 2

1. NO ZENITH ANGLE CRITERION IMPOSED

2. NO RESTRICTIONS ON ACCEPTABLE HEIGHTS

NORMAL EXIT. EXECUTION TIME: 30268 MLSEC.
@FIN

RUNID: 4G11 ACCT: 111AC116 PROJECT: ROPER-R-G

TIME: TOTAL: 00:11:21.324

CPU: 00:01:28.132 I/O: 00:09:18.929

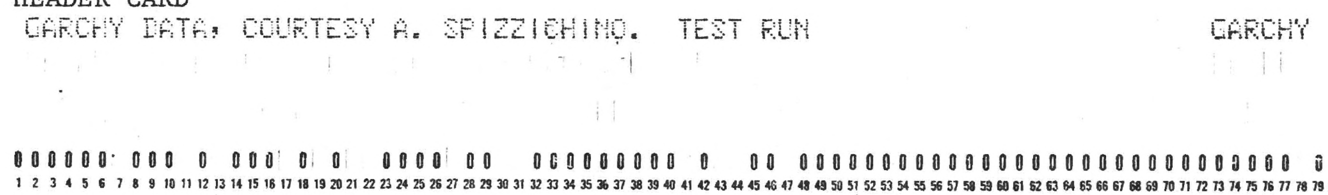
CC/ER: 00:00:34.263 WAIT: 00:00:05.030

IMAGES READ: 24 PAGES: 89

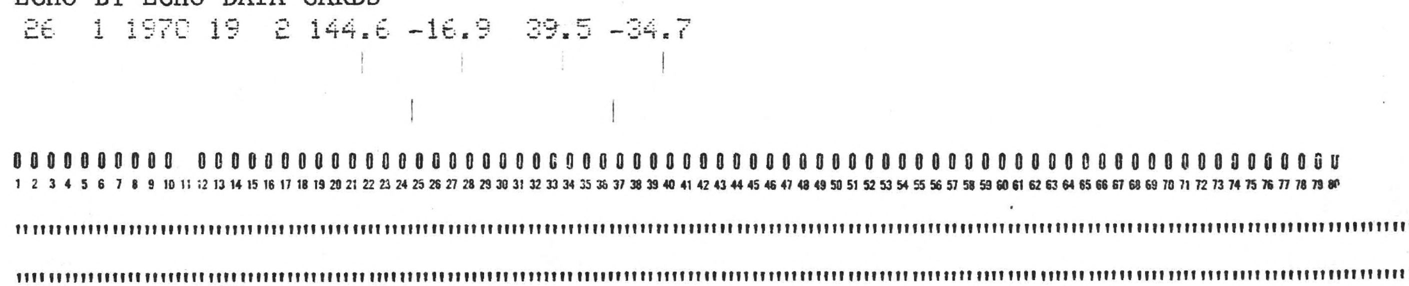
START: 15:46:34 JUN 11,1974 FIN: 16:01:12 JUN 11,1974

PROGRAM LØADIT

HEADER CARD



ECHO BY ECHO DATA CARDS



BLANK CARD

@FIN

PROGRAM GRØVES (ROUTINE WIND ANALYSIS)

DATA INTERVAL TO BE PROCESSED

750815   750908

NUMBER OF HARMONICS IN TIME SERIES (INCLUDING FUNDAMENTAL)

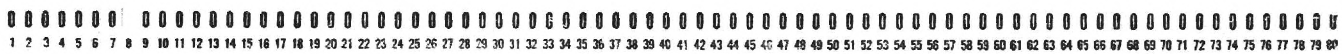
3 3 3

FUNDAMENTAL PERIOD (HOURS)

24.0

HEIGHT RANGE

76 106



[CONTINUED ON NEXT PAGE]

GRØVES DATA (CONTINUED)

ORDERS OF POLYNOMIALS FITTED TO EAST-WEST PROFILES

3 3 3 3

ORDERS OF POLYNOMIALS FITTED TO NORTH-SOUTH PROFILES

3 3 3 3

ORDERS OF POLYNOMIALS FITTED TO VERTICAL PROFILES

0 0 0 0

@FIN

[REQUIRES ECHO BY ECHO DATA (METEØR, DECØDE OR LØADIT OUTPUT) ON UNIT 4]

(ALL DATA IN FILE)

DATA INTERVAL   740824 TO 740904

VARIATION OF UPPER ATMOSPHERE WINDS WITH HEIGHT GROVES ANALYSIS,WITH ERROR DETERMINATION

NUMBER OF METEORS PROCESSED = 415

NUMBER OF INPUT PARAMETERS = 63

DATA READ FROM MASS STORAGE FILE

TIME SERIES PARAMETERS P = 3, Q = 3, R = 3

HEIGHT RANGE,   MAXIMUM   106   MINIMUM   76

POWER SERIES PARAMETERS

NA	3	3	3	3	0	0	0	0	0	0	0
NB	3	3	3	3	0	0	0	0	0	0	0
NC	0	0	0	0	0	0	0	0	0	0	0

PERIOD   24.0 HOURS

RESULTS FOR AUGUST 24 - SEPTEMBER 4, 1974 GT FACILITY RUN ON SEP 6, 1974 ATLANTA PAGE 2

(ALL DATA IN FILE)

ECHO RATE AS A FUNCTION OF TIME AND HEIGHT.

HEIGHT	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
105	2	2	3	2	0	2	1	2	0	0	0	0	1	2	1	2	1	2	1	2	0	0	1	0
103	0	0	0	1	2	1	0	1	2	0	1	0	1	0	1	2	2	2	2	0	2	0	2	1
101	1	0	1	3	2	0	1	0	1	0	0	0	0	0	0	1	2	1	0	2	1	3	3	0
99	3	2	3	3	3	0	2	2	0	2	0	0	0	0	0	2	0	2	2	3	2	1	8	2
97	2	0	2	1	3	0	1	1	1	3	0	0	0	0	1	3	1	2	2	2	0	0	2	4
95	1	0	4	1	2	2	4	1	0	0	0	1	0	1	0	1	2	1	0	3	2	3	3	3
93	1	0	2	0	4	2	0	1	0	1	0	0	0	2	1	3	4	1	2	2	0	0	1	1
91	0	2	0	1	1	0	1	0	0	1	2	0	1	1	1	0	1	1	5	0	1	1	3	1
89	1	1	5	2	4	0	0	1	1	0	0	0	0	0	2	2	0	1	1	2	0	4	3	1
87	0	3	1	3	0	1	1	1	1	1	0	0	1	0	2	2	1	1	1	5	0	3	0	1
85	2	1	2	1	4	0	2	3	0	2	2	0	1	0	0	2	1	2	1	2	1	1	0	0
83	0	3	2	5	3	4	0	1	1	1	0	0	0	0	2	1	2	1	1	2	1	2	1	0
81	0	1	0	2	5	1	2	0	0	0	1	0	0	1	1	1	0	0	2	0	0	0	2	0
79	0	1	2	1	2	1	0	2	0	1	0	0	1	1	1	3	1	1	1	1	1	1	1	1
77	1	1	0	0	1	3	0	2	2	1	0	0	0	0	2	4	2	1	0	2	0	1	1	1

(ALL DATA IN FILE)

LOG (BASE 10) OF MATRIX DETERMINANT .234175+02

COLUMN MATRIX AC(K)

19.87	6.3
13.34	21.6
-23.61	20.4
-20.22	40.3
3.12	7.3
-16.89	23.5
-4.40	22.5
26.04	42.7
-11.68	7.9
15.77	24.9
17.47	24.1
-.30	44.7
13.88	8.2
-19.82	26.4
-26.03	25.9
36.33	49.2
-27.61	10.2
-56.81	36.9
18.89	34.2
97.16	71.3
-6.91	9.1
-21.40	32.7
27.97	30.2
50.59	62.6
-7.32	8.2
-.40	29.3
9.52	28.5
3.45	58.4
-3.91	5.1
-20.77	17.5
5.83	16.7
25.56	32.2
4.96	6.3
34.41	19.8
29.05	19.3
-36.89	35.3
-1.15	6.6
-7.81	20.7
-5.28	21.0
16.90	37.6
-1.59	6.6
-20.38	22.7
.40	21.5
36.45	41.0
1.29	8.0

(ALL DATA IN FILE)

COLUMN MATRIX AC(K)

2.09	29.1
-21.66	27.0
4.49	53.9
-9.31	7.6
32.98	27.7
12.98	24.1
-70.18	49.7
-.87	7.1
-16.31	24.0
-7.82	22.3
37.22	43.9
-1.60	3.6
3.08	4.0
-3.79	4.4
14.79	4.5
8.74	5.9
-8.99	5.0
2.33	4.3

RESULTS FOR AUGUST 24 - SEPTEMBER 4, 1974 GT FACILITY RUN ON SEP 6, 1974 ATLANTA PAGE 5

(ALL DATA IN FILE)

EAST-WEST COMPONENTS OF THE MEAN WIND, HOUR BY HOUR,

AS DETERMINED FOR THE HEIGHT RANGE 76 KM TO 106 KM.

HEIGHT	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
106	83.	60.	36.	0.	-35.	-57.	-65.	-58.	-42.	-23.	-7.	3.	4.	-3.	-17.	-35.	-53.	-64.	-65.	-50.	-22.	15.	51.	77.
104	36.	30.	17.	-0.	-16.	-27.	-29.	-23.	-12.	3.	17.	27.	30.	25.	14.	-1.	-17.	-29.	-34.	-30.	-17.	1.	18.	31.
102	3.	4.	5.	0.	-3.	-4.	-3.	3.	13.	24.	35.	43.	46.	42.	33.	21.	8.	-2.	-10.	-13.	-13.	-10.	-5.	-1.
100	-18.	-11.	-4.	2.	6.	10.	15.	22.	31.	41.	49.	54.	54.	49.	42.	34.	26.	17.	9.	-0.	-9.	-16.	-21.	-21.
98	-28.	-18.	-7.	4.	12.	19.	26.	35.	44.	52.	58.	58.	55.	49.	43.	39.	35.	30.	22.	10.	-5.	-19.	-29.	-32.
96	-30.	-18.	-5.	6.	14.	22.	31.	42.	53.	60.	63.	59.	51.	43.	38.	37.	39.	38.	31.	17.	-2.	-20.	-32.	-35.
94	-26.	-14.	-2.	8.	14.	22.	32.	45.	57.	65.	65.	56.	44.	33.	29.	31.	37.	40.	36.	22.	1.	-18.	-31.	-33.
92	-18.	-6.	3.	9.	13.	18.	29.	44.	58.	66.	64.	51.	34.	21.	17.	22.	32.	39.	37.	24.	4.	-15.	-26.	-26.
90	-8.	2.	8.	10.	10.	13.	24.	41.	57.	65.	60.	45.	24.	9.	4.	12.	25.	35.	35.	24.	6.	-11.	-19.	-18.
88	0.	9.	12.	9.	6.	8.	19.	36.	53.	61.	56.	38.	15.	-2.	-7.	1.	16.	29.	32.	23.	8.	-6.	-12.	-9.
86	6.	12.	12.	7.	2.	3.	14.	31.	48.	56.	50.	31.	8.	-10.	-15.	-8.	7.	21.	26.	21.	9.	-1.	-5.	-1.
84	8.	11.	9.	4.	-1.	0.	10.	26.	42.	49.	44.	27.	5.	-12.	-19.	-13.	0.	13.	19.	17.	10.	2.	-0.	2.
82	2.	2.	1.	-2.	-3.	0.	9.	23.	35.	41.	38.	25.	8.	-7.	-15.	-13.	-5.	5.	12.	13.	10.	5.	1.	1.
80	-13.	-15.	-14.	-10.	-3.	4.	13.	22.	29.	33.	32.	27.	17.	6.	-3.	-7.	-6.	-1.	5.	9.	9.	5.	-1.	-8.
78	-40.	-44.	-37.	-20.	-1.	14.	22.	24.	23.	24.	28.	33.	35.	30.	20.	7.	-3.	-6.	-2.	5.	8.	4.	-9.	-26.
76	-80.	-86.	-66.	-34.	3.	30.	37.	30.	19.	16.	26.	45.	62.	67.	55.	32.	7.	-7.	-7.	1.	6.	-1.	-24.	-55.

RESULTS FOR AUGUST 24 - SEPTEMBER 4, 1974 GT FACILITY RUN ON SEP 6, 1974 ATLANTA PAGE 6

(ALL DATA IN FILE)

NORTH-SOUTH COMPONENTS OF THE MEAN WIND, HOUR BY HOUR,

AS DETERMINED FOR THE HEIGHT RANGE 76 KM TO 106 KM.

HEIGHT	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
106	-7.	11.	24.	34.	45.	57.	67.	68.	55.	30.	-0.	-25.	-35.	-26.	-5.	18.	29.	24.	2.	-25.	-47.	-55.	-47.	-28.
104	-11.	2.	15.	26.	36.	44.	47.	45.	36.	21.	4.	-11.	-20.	-22.	-19.	-13.	-10.	-12.	-19.	-29.	-36.	-38.	-34.	-24.
102	-14.	-4.	0.	20.	29.	33.	32.	28.	21.	14.	6.	-2.	-11.	-19.	-26.	-32.	-34.	-33.	-31.	-29.	-27.	-26.	-25.	-21.
100	-16.	-8.	4.	15.	23.	25.	22.	16.	10.	7.	4.	1.	-6.	-17.	-29.	-40.	-45.	-43.	-35.	-26.	-20.	-17.	-18.	-18.
98	-16.	-10.	1.	12.	19.	19.	15.	8.	3.	1.	1.	0.	-5.	-15.	-29.	-40.	-45.	-42.	-33.	-22.	-14.	-11.	-13.	-16.
96	-15.	-10.	-1.	9.	15.	16.	11.	4.	-1.	-3.	-3.	-3.	-6.	-14.	-25.	-34.	-38.	-35.	-26.	-16.	-10.	-8.	-11.	-15.
94	-14.	-10.	-2.	7.	13.	13.	9.	3.	-3.	-6.	-7.	-7.	-9.	-13.	-19.	-24.	-26.	-23.	-17.	-10.	-6.	-7.	-10.	-14.
92	-13.	-8.	-1.	6.	11.	12.	9.	3.	-3.	-8.	-11.	-12.	-12.	-12.	-12.	-12.	-11.	-9.	-6.	-4.	-4.	-7.	-10.	-13.
90	-11.	-7.	-1.	5.	10.	12.	10.	6.	-1.	-7.	-13.	-15.	-14.	-11.	-6.	-0.	4.	6.	5.	2.	-3.	-8.	-11.	-13.
88	-10.	-5.	0.	6.	10.	12.	12.	9.	3.	-5.	-12.	-16.	-15.	-9.	0.	10.	16.	18.	14.	6.	-2.	-9.	-13.	-13.
86	-9.	-4.	1.	6.	10.	13.	14.	12.	7.	-1.	-9.	-14.	-13.	-6.	5.	16.	24.	25.	19.	9.	-2.	-10.	-14.	-13.
84	-10.	-4.	2.	7.	11.	14.	16.	15.	11.	5.	-2.	-7.	-7.	-3.	6.	16.	23.	25.	19.	9.	-2.	-11.	-15.	-14.
82	-11.	-5.	2.	8.	12.	14.	16.	16.	16.	14.	11.	7.	3.	2.	4.	8.	12.	15.	13.	7.	-2.	-10.	-14.	-15.
80	-14.	-7.	2.	9.	13.	14.	14.	16.	20.	25.	29.	27.	20.	8.	-3.	-10.	-11.	-7.	-2.	0.	-1.	-7.	-13.	-16.
78	-18.	-11.	0.	10.	14.	13.	10.	12.	23.	39.	53.	56.	43.	16.	-15.	-40.	-50.	-44.	-27.	-10.	-0.	-2.	-9.	-17.
76	-25.	-18.	-3.	11.	15.	10.	3.	6.	24.	55.	84.	95.	74.	26.	-34.	-84.	-107.	-97.	-64.	-25.	1.	7.	-4.	-19.

RESULTS FOR AUGUST 24 - SEPTEMBER 4, 1974   GT FACILITY   RUN ON SEP 6, 1974   ATLANTA   PAGE 7

(ALL DATA IN FILE)

VERTICAL COMPONENT OF THE MEAN WIND, HOUR BY HOUR,

AS DETERMINED FOR THE HEIGHT RANGE 76 KM TO 106 KM.

HEIGHT	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
106	10.	15.	12.	4.	-3.	-4.	-0.	7.	10.	6.	-6.	-22.	-33.	-33.	-23.	-5.	11.	19.	16.	6.	-6.	-12.	-9.	0.
104	10.	15.	12.	4.	-3.	-4.	-0.	7.	10.	6.	-6.	-22.	-33.	-33.	-23.	-5.	11.	19.	16.	6.	-6.	-12.	-9.	0.
102	10.	15.	12.	4.	-3.	-4.	-0.	7.	10.	6.	-6.	-22.	-33.	-33.	-23.	-5.	11.	19.	16.	6.	-6.	-12.	-9.	0.
100	10.	15.	12.	4.	-3.	-4.	-0.	7.	10.	6.	-6.	-22.	-33.	-33.	-23.	-5.	11.	19.	16.	6.	-6.	-12.	-9.	0.
98	10.	15.	12.	4.	-3.	-4.	-0.	7.	10.	6.	-6.	-22.	-33.	-33.	-23.	-5.	11.	19.	16.	6.	-6.	-12.	-9.	0.
96	10.	15.	12.	4.	-3.	-4.	-0.	7.	10.	6.	-6.	-22.	-33.	-33.	-23.	-5.	11.	19.	16.	6.	-6.	-12.	-9.	0.
94	10.	15.	12.	4.	-3.	-4.	-0.	7.	10.	6.	-6.	-22.	-33.	-33.	-23.	-5.	11.	19.	16.	6.	-6.	-12.	-9.	0.
92	10.	15.	12.	4.	-3.	-4.	-0.	7.	10.	6.	-6.	-22.	-33.	-33.	-23.	-5.	11.	19.	16.	6.	-6.	-12.	-9.	0.
90	10.	15.	12.	4.	-3.	-4.	-0.	7.	10.	6.	-6.	-22.	-33.	-33.	-23.	-5.	11.	19.	16.	6.	-6.	-12.	-9.	0.
88	10.	15.	12.	4.	-3.	-4.	-0.	7.	10.	6.	-6.	-22.	-33.	-33.	-23.	-5.	11.	19.	16.	6.	-6.	-12.	-9.	0.
86	10.	15.	12.	4.	-3.	-4.	-0.	7.	10.	6.	-6.	-22.	-33.	-33.	-23.	-5.	11.	19.	16.	6.	-6.	-12.	-9.	0.
84	10.	15.	12.	4.	-3.	-4.	-0.	7.	10.	6.	-6.	-22.	-33.	-33.	-23.	-5.	11.	19.	16.	6.	-6.	-12.	-9.	0.
82	10.	15.	12.	4.	-3.	-4.	-0.	7.	10.	6.	-6.	-22.	-33.	-33.	-23.	-5.	11.	19.	16.	6.	-6.	-12.	-9.	0.
80	10.	15.	12.	4.	-3.	-4.	-0.	7.	10.	6.	-6.	-22.	-33.	-33.	-23.	-5.	11.	19.	16.	6.	-6.	-12.	-9.	0.
78	10.	15.	12.	4.	-3.	-4.	-0.	7.	10.	6.	-6.	-22.	-33.	-33.	-23.	-5.	11.	19.	16.	6.	-6.	-12.	-9.	0.
76	10.	15.	12.	4.	-3.	-4.	-0.	7.	10.	6.	-6.	-22.	-33.	-33.	-23.	-5.	11.	19.	16.	6.	-6.	-12.	-9.	0.

RESULTS FOR AUGUST 24 - SEPTEMBER 4, 1974 GT FACILITY RUN ON SEP 6, 1974 ATLANTA PAGE 8

(ALL DATA IN FILE)

EAST-WEST COMPONENTS OF THE MEAN WIND, AMPLITUDE AND PHASE,

AS DETERMINED FOR THE HEIGHT RANGE 76 KM TO 106 KM.

			24.0 HOUR COMPONENT				12.0 HOUR COMPONENT				8.0 HOUR COMPONENT			
HEIGHT	MEAN	ERROR	AMP	ERROR	PHASE	ERROR	AMP	ERROR	PHASE	ERROR	AMP	ERROR	PHASE	ERROR
106	-11.	29.	33.	49.4	.9	4.	55.	39.8	.8	1.	7.	39.1	.9	8.
104	1.	18.	2.	20.0	5.0	56.	32.	24.1	.9	2.	2.	24.5	.6	17.
102	9.	12.	21.	20.6	12.3	2.	15.	15.2	1.2	2.	1.	15.8	4.4	17.
100	15.	9.	34.	15.9	12.3	1.	4.	11.0	2.4	6.	3.	12.3	3.8	4.
98	19.	9.	40.	14.5	12.3	1.	6.	12.5	6.2	3.	6.	10.7	3.4	2.
96	21.	8.	41.	13.4	12.2	1.	10.	11.1	6.9	2.	8.	9.6	3.1	2.
94	21.	7.	37.	11.8	12.0	1.	12.	9.4	7.3	1.	12.	8.7	2.8	1.
92	21.	6.	31.	10.4	11.8	1.	13.	8.3	7.7	1.	14.	8.1	2.7	1.
90	19.	6.	24.	10.3	11.3	1.	14.	8.2	8.2	1.	17.	8.3	2.6	1.
88	16.	7.	17.	11.2	10.6	2.	14.	8.7	8.7	1.	18.	9.1	2.5	1.
86	14.	8.	13.	11.7	9.6	3.	15.	9.5	9.2	1.	17.	9.8	2.5	1.
84	11.	8.	10.	11.5	8.9	4.	16.	10.1	9.5	1.	15.	10.1	2.5	1.
82	8.	8.	10.	12.6	9.5	4.	16.	10.5	9.6	1.	10.	10.3	2.6	2.
80	5.	11.	14.	18.1	11.2	3.	14.	12.4	9.5	2.	3.	16.5	4.0	5.
78	4.	18.	28.	30.6	12.3	3.	12.	18.9	9.0	4.	12.	20.0	5.8	3.
76	3.	29.	50.	50.6	12.8	2.	13.	38.3	7.7	6.	29.	32.5	6.0	2.

(ALL DATA IN FILE)

NORTH-SOUTH COMPONENTS OF THE MEAN WIND, AMPLITUDE AND PHASE

AS DETERMINED FOR THE HEIGHT RANGE 76 KM TO 106 KM.

			24.0 HOUR COMPONENT				12.0 HOUR COMPONENT				8.0 HOUR COMPONENT			
HEIGHT	MEAN	ERROR	AMP	ERROR	PHASE	ERROR	AMP	ERROR	PHASE	ERROR	AMP	ERROR	PHASE	ERROR
106	7.	22.	34.	30.2	7.6	4.	34.	31.2	5.8	2.	19.	25.8	1.1	2.
104	-1.	14.	34.	17.7	7.2	2.	17.	19.1	6.1	2.	6.	15.7	1.2	4.
102	-6.	9.	32.	10.8	6.8	2.	7.	12.9	6.9	3.	3.	11.1	4.9	5.
100	-9.	8.	28.	8.3	6.6	2.	4.	8.9	9.0	6.	8.	10.1	5.0	2.
98	-10.	7.	24.	8.0	6.3	2.	5.	8.2	9.8	5.	10.	10.0	5.1	1.
96	-9.	7.	18.	7.7	6.1	2.	4.	8.0	9.3	5.	9.	9.3	5.1	1.
94	-8.	6.	13.	7.1	5.7	3.	4.	8.7	7.5	4.	7.	8.2	5.2	1.
92	-5.	5.	7.	6.5	5.3	4.	7.	7.9	6.4	2.	4.	7.2	5.2	2.
90	-3.	5.	3.	6.5	4.6	10.	11.	7.7	6.1	1.	0.	6.6	6.8	31.
88	0.	5.	0.	6.8	17.8	72.	15.	8.5	6.0	1.	3.	7.8	1.1	3.
86	3.	6.	3.	8.8	14.9	12.	16.	9.4	6.0	1.	5.	8.5	1.3	2.
84	4.	6.	5.	10.3	12.8	6.	15.	9.8	6.0	1.	4.	8.8	1.6	2.
82	5.	7.	9.	11.0	10.8	4.	9.	10.5	6.4	2.	3.	9.2	2.7	4.
80	4.	9.	17.	14.1	9.6	3.	5.	11.8	9.4	5.	8.	13.4	4.1	2.
78	2.	15.	29.	21.1	8.9	3.	20.	21.1	11.1	2.	18.	21.3	4.5	1.
76	-3.	25.	45.	32.4	8.4	3.	44.	35.5	11.3	1.	34.	34.1	4.7	1.

(ALL DATA IN FILE)

VERTICAL COMPONENTS OF THE MEAN WIND, AMPLITUDE AND PHASE

AS DETERMINED FOR THE HEIGHT RANGE 76 KM TO 106 KM.

			24.0 HOUR COMPONENT				12.0 HOUR COMPONENT				8.0 HOUR COMPONENT			
HEIGHT	MEAN	ERROR	AMP	ERROR	PHASE	ERROR	AMP	ERROR	PHASE	ERROR	AMP	ERROR	PHASE	ERROR
106	-2.	4.	9.	5.7	1.3	2.	10.	5.0	6.8	1.	15.	4.5	1.8	0.
104	-2.	4.	9.	5.7	1.3	2.	10.	5.0	6.8	1.	15.	4.5	1.8	0.
102	-2.	4.	9.	5.7	1.3	2.	10.	5.0	6.8	1.	15.	4.5	1.8	0.
100	-2.	4.	9.	5.7	1.3	2.	10.	5.0	6.8	1.	15.	4.5	1.8	0.
98	-2.	4.	9.	5.7	1.3	2.	10.	5.0	6.8	1.	15.	4.5	1.8	0.
96	-2.	4.	9.	5.7	1.3	2.	10.	5.0	6.8	1.	15.	4.5	1.8	0.
94	-2.	4.	9.	5.7	1.3	2.	10.	5.0	6.8	1.	15.	4.5	1.8	0.
92	-2.	4.	9.	5.7	1.3	2.	10.	5.0	6.8	1.	15.	4.5	1.8	0.
90	-2.	4.	9.	5.7	1.3	2.	10.	5.0	6.8	1.	15.	4.5	1.8	0.
88	-2.	4.	9.	5.7	1.3	2.	10.	5.0	6.8	1.	15.	4.5	1.8	0.
86	-2.	4.	9.	5.7	1.3	2.	10.	5.0	6.8	1.	15.	4.5	1.8	0.
84	-2.	4.	9.	5.7	1.3	2.	10.	5.0	6.8	1.	15.	4.5	1.8	0.
82	-2.	4.	9.	5.7	1.3	2.	10.	5.0	6.8	1.	15.	4.5	1.8	0.
80	-2.	4.	9.	5.7	1.3	2.	10.	5.0	6.8	1.	15.	4.5	1.8	0.
78	-2.	4.	9.	5.7	1.3	2.	10.	5.0	6.8	1.	15.	4.5	1.8	0.
76	-2.	4.	9.	5.7	1.3	2.	10.	5.0	6.8	1.	15.	4.5	1.8	0.

PROGRAM ERG (WIND SPECTRUM ANALYSIS)

```
DATA INTERVAL
750815   750908

HEIGHT RANGE
   76 106

PROFILE POLYNOMIAL SPECIFICATIONS
    3     3     3     3     0     0

SPECTRUM INTERVAL AND RESOLUTION
   0.5  4.0 0.05

@FIN
```

[REQUIRES THE SAME ECHO INPUT DATA AS GRØVES, ON UNIT 4]

SPECTRUM ANALYSIS

VARIATION OF UPPER ATMOSPHERE WINDS WITH HEIGHT

BASED ON GROVES ANALYSIS, WITH ERROR DETERMINATION

NUMBER OF METEORS PROCESSED = 415

NUMBER OF INPUT PARAMETERS = 27

HEIGHT RANGE, MAXIMUM 106 MINIMUM 76 KILOMETERS.

EAST-WEST PROFILE 3 3

NORTH-SOUTH PROFILE 3 3

VERTICAL PARAMETERS 0 0

ALL DATA IN FILE 740824 740904 FREQUENCY .5000 CYCLES/DAY.

COLUMNS MATRIX AC (K)

12.52	5.2
.66	16.5
-16.85	16.3
-7.78	30.9
.74	8.1
-11.55	26.1
2.75	23.2
-8.91	44.8
-6.34	6.7
11.51	21.4
15.33	22.4
-8.35	42.8
-4.44	4.5
-27.78	14.2
-1.17	13.2
46.56	24.7
2.80	6.9
-19.90	22.0
-26.77	19.9
38.21	37.7
-15.36	5.7
15.62	18.2
16.49	17.4
-17.19	32.4
4.55	3.0
13.42	4.9
-3.63	3.7

AUG 24, 1974 TO SEP 4, 1974 FREQUENCY .5000 CYCLES/DAY.

EAST-WEST COMPONENTS OF THE MEAN WIND//

HEIGHT	76	78	80	82	84	86	88	90	92	94	96	98	100	102	104	106
MEAN	3.	4.	6.	8.	9.	11.	12.	12.	12.	12.	11.	8.	5.	1.	-5.	-11.
ERROR	21.	13.	8.	7.	6.	6.	6.	5.	5.	6.	6.	6.	7.	10.	15.	24.
AMP	25.	19.	15.	12.	11.	10.	9.	7.	6.	4.	3.	5.	8.	12.	16.	21.
ERROR	29.	18.	12.	10.	10.	9.	8.	7.	7.	7.	10.	10.	10.	13.	19.	31.
PHASE	10.2	11.7	13.7	15.9	17.9	19.7	21.1	22.4	24.0	27.2	33.4	38.3	40.1	40.8	40.9	40.7
ERROR	9.6	7.8	6.3	5.6	6.4	7.1	7.7	8.6	11.4	17.5	18.3	12.2	9.3	9.1	10.6	13.0

NORTH-SOUTH COMPONENTS OF THE MEAN WIND

HEIGHT	76	78	80	82	84	86	88	90	92	94	96	98	100	102	104	106
MEAN	-24.	-12.	-3.	2.	4.	3.	1.	-3.	-6.	-10.	-12.	-13.	-11.	-7.	1.	13.
ERROR	19.	12.	8.	6.	6.	5.	5.	5.	5.	5.	5.	6.	6.	7.	10.	17.
AMP	42.	25.	16.	15.	17.	19.	18.	17.	14.	12.	10.	10.	11.	11.	10.	6.
ERROR	28.	17.	11.	8.	7.	7.	6.	6.	6.	6.	8.	9.	9.	11.	16.	26.
PHASE	36.5	34.4	30.3	25.6	23.0	21.9	21.7	22.2	23.3	25.3	28.1	31.1	33.4	34.8	35.5	35.4
ERROR	4.6	4.8	5.1	4.4	3.7	3.2	3.0	3.2	3.8	4.9	5.8	5.6	5.2	6.1	10.7	29.6

VERTICAL COMPONENTS OF THE WIND

HEIGHT	76	78	80	82	84	86	88	90	92	94	96	98	100	102	104	106
MEAN	5.	5.	5.	5.	5.	5.	5.	5.	5.	5.	5.	5.	5.	5.	5.	5.
ERROR	3.	3.	3.	3.	3.	3.	3.	3.	3.	3.	3.	3.	3.	3.	3.	3.
AMP	14.	14.	14.	14.	14.	14.	14.	14.	14.	14.	14.	14.	14.	14.	14.	14.
ERROR	5.	5.	5.	5.	5.	5.	5.	5.	5.	5.	5.	5.	5.	5.	5.	5.
PHASE	14.0	14.0	14.0	14.0	14.0	14.0	14.0	14.0	14.0	14.0	14.0	14.0	14.0	14.0	14.0	14.0
ERROR	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0

END OF PASS 1

RESULTS FOR AUGUST 24 - SEPTEMBER 4, 1974 GT FACILITY PERIOD 6.00 HOURS ATLANTA PAGE 142

AUG 24, 1974 TO SEP 4, 1974 FREQUENCY 4.0000 CYCLES/DAY.

COLUMNS MATRIX AC (K)

18.60	5.0
-1.95	16.5
-27.77	16.1
-7.67	31.1
24.98	6.9
1.96	22.7
-43.01	22.9
-33.64	44.4
7.84	7.3
.36	23.8
-28.13	22.5
-19.57	43.0
-1.84	4.3
-33.15	14.1
1.60	13.2
53.35	24.8
-1.83	6.0
-27.77	19.5
3.21	18.7
33.91	35.3
-2.38	6.1
-14.90	19.8
12.61	18.5
11.30	34.3
4.60	2.8
3.10	3.9
11.50	4.1

RESULTS FOR AUGUST 24 - SEPTEMBER 4, 1974 GT FACILITY PERIOD 6.00 HOURS ATLANTA PAGE 143

AUG 24, 1974 TO SEP 4, 1974 FREQUENCY 4.0000 CYCLES/DAY.

EAST-WEST COMPONENTS OF THE MEAN WIND//

HEIGHT	76	78	80	82	84	86	88	90	92	94	96	98	100	102	104	106
MEAN	0.	4.	8.	11.	14.	16.	18.	19.	18.	17.	15.	11.	6.	-1.	-9.	-19.
ERROR	22.	14.	9.	7.	6.	6.	6.	5.	5.	5.	6.	6.	7.	9.	15.	23.
AMP	14.	13.	14.	16.	18.	21.	24.	26.	26.	24.	20.	13.	7.	18.	38.	63.
ERROR	34.	21.	13.	9.	9.	8.	8.	7.	7.	8.	8.	9.	10.	14.	22.	35.
PHASE	1.6	1.6	1.5	1.4	1.3	1.3	1.2	1.2	1.2	1.2	1.3	1.5	2.5	3.6	3.8	3.9
ERROR	2.0	1.3	.8	.6	.5	.4	.3	.3	.3	.3	.4	.7	1.3	.6	.5	.5

NORTH-SOUTH COMPONENTS OF THE MEAN WIND

HEIGHT	76	78	80	82	84	86	88	90	92	94	96	98	100	102	104	106
MEAN	-20.	-7.	2.	7.	9.	7.	4.	0.	-4.	-8.	-11.	-12.	-10.	-4.	5.	20.
ERROR	19.	12.	8.	6.	6.	5.	5.	4.	4.	5.	5.	6.	6.	7.	10.	17.
AMP	15.	13.	13.	12.	10.	7.	4.	1.	5.	8.	11.	12.	11.	7.	2.	10.
ERROR	27.	16.	10.	8.	8.	7.	7.	6.	6.	7.	7.	8.	8.	10.	14.	25.
PHASE	5.7	.2	.5	.8	.9	1.0	1.2	3.0	3.8	3.9	4.0	4.0	4.1	4.2	5.3	.8
ERROR	1.7	1.3	.9	.7	.7	1.0	1.7	4.3	1.2	.7	.6	.6	.7	1.2	7.3	2.1

VERTICAL COMPONENTS OF THE WIND

HEIGHT	76	78	80	82	84	86	88	90	92	94	96	98	100	102	104	106
MEAN	5.	5.	5.	5.	5.	5.	5.	5.	5.	5.	5.	5.	5.	5.	5.	5.
ERROR	3.	3.	3.	3.	3.	3.	3.	3.	3.	3.	3.	3.	3.	3.	3.	3.
AMP	12.	12.	12.	12.	12.	12.	12.	12.	12.	12.	12.	12.	12.	12.	12.	12.
ERROR	4.	4.	4.	4.	4.	4.	4.	4.	4.	4.	4.	4.	4.	4.	4.	4.
PHASE	.3	.3	.3	.3	.3	.3	.3	.3	.3	.3	.3	.3	.3	.3	.3	.3
ERROR	.3	.3	.3	.3	.3	.3	.3	.3	.3	.3	.3	.3	.3	.3	.3	.3

END OF PASS 71
215 RECORDS WRITEN IN F2 FILE

NORMAL EXIT. EXECUTION TIME: 309003 MLSEC.
@FIN

Meteor Winds Over Atlanta (34° N, 84° W)

August 1974 - July 1975

by

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Presented at the XVIth General Assembly of the IUGG, Grenoble, France, August 25 - September 6, 1975 in IS-22, "Stratosphere-Mesosphere Relations," jointly sponsored by IAGA/IAMAP.

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ABSTRACT

An all sky, continuous wave radio meteor wind facility has been installed in Atlanta by the Georgia Institute of Technology under National Science Foundation sponsorship. A double sideband suppressed carrier CW transmitter, operating on 32.5 MHz $\pm$ 360 Hz, with an RMS output of 2 KW, has been installed on the Georgia Tech campus, and a receiving site established at Technology Park/Atlanta, 27 kilometers northeast of the campus. Details of the equipment, together with height/time profiles of mean wind circulation and tides between 80 and 100 kilometers, measured from August 1974 to July 1975, are presented.

INTRODUCTION

The Georgia Tech Radio Meteor Wind Facility which has been in continuous operation since August 9, 1974, is described in detail in Roper (1975). Individual meteor wind dopplers are measured to an accuracy of 3 m/sec, and reflection center heights to $\pm$ 2 km. This resolution is ample for the determination of the prevailing and tidal wind observations presented here. Winds are determined by matching the measured line of sight drifts to a model, using the analysis of Groves (1959). Details of the technique are given in Roper (1975).

RESULTS

The results of continuous measurements made from August 9, 1974, through July 28, 1975, less six weeks in April/May, appear in Figure 1 through 4. Only a preliminary assessment of the significance of these results, with particular emphasis on the stratwarm period of January 1 through 17, 1975, is presented here. A more detailed evaluation will eventually be published elsewhere.

In analyzing the raw data, mean values of the prevailing wind, 48, 24, and 12 hour components were extracted over 5 to 10 day intervals, the longer intervals being analyzed when useable echo rates were down. The two day period was extracted simply because it has been noticed on odd occasions at other meteor wind stations, particularly in January data, and was considered as a possible indicator of "planetary wave" penetration into the meteor region from below.

Both the zonal and meridional components of the prevailing wind (the "constant" term in the Fourier series best fitting the data over each interval analyzed) are shown in Figure 1. These results are at variance with the average annual behavior reported by Barnes (1973) for predominately higher northern latitudes (summer and winter, mean zonal westerlies , with equinoxial easterlies) and Elford (1974) for Adelaide, Australia, 35° S, 139° E (Predominant zonal westerlies, maximizing in summer and winter). While I hesitate to make seasonal inferences from only one years data, the winter easterlies are not in keeping with the expected behavior; there is also some intriguing structure in the flow - an easing of the easterly flow, with a weak reversal, in late December, a return to easterlies in January, and then a rapid switch to westerlies in February. It is tempting to associate this sequence of changes in December through February with the polar stratwarm of December 15 through February 15 reported by Quiroz et al (1975), and regarded as a major warming January 1 through 17. The meridional flow is characterized by generally lower wind speeds, a change from northerly flow in summer to southerly flow in winter (in keeping with a warm winter pole at meteor altitudes) with some structure in December-January.

Figure 2 shows zonal and meridional height time profiles of the amplitude of the 48 hour component. Greatest amplitudes, associated with maximum rates of change of amplitude with both height and time, occur in late December - early January.

In the diurnal (24 hour) component amplitudes, there is evidence of equinoctial maxima (Roper, 1975), but again there is considerable structure in the late December - early January period.

In contrast, the semidiurnal (12 hour) component amplitude variations, in addition to being somewhat more complicated, exhibit minimum amplitudes in late December - early January.

CONCLUSIONS

This very preliminary assessment of one year of radio meteor winds measured over Atlanta (34° N, 84° W) demonstrates that continuous recording of radio meteor wind data reveals week by week variations in prevailing, possible planetary wave, diurnal and semidiurnal components which may be able to be directly related to the meteorology of the atmosphere below. In particular, this set of data shows intriguing structure in wind patterns measured over the period of the stratwarm of January 1-17, 1975.

REFERENCES

Barnes, Arnold A., Jr. "Status report on radar meteor wind and density measurements", Bull. Amer. Meteorol. Soc., 54, 900-910, 1973.

Elford, W. G., "A six year synoptic study of winds between 80 and 100 km, from meteor trail drifts", Proceedings of the International Conference on the Structure, Composition and General Circulation of the Upper and Lower Atmospheres, Melbourne, Australia, 2, 624, 641, 1974.

Groves, G. V., "A theory for determining upper atmosphere winds from radio observations on meteor trails", J. Atmos. Terr. Phys., 16, 344-356, 1959.

Quiroz, R. S., A. J. Miller, and R. M. Nagatani, "A comparison of observed and simulated properties of sudden stratospheric warmings," J. Atmos. Sci., 32, September, 1975 (in press).

Roper, R. G., "The measurement of meteor winds over Atlanta (34° N, 84° W)", Radio Sci., 10, 363-369, 1975.

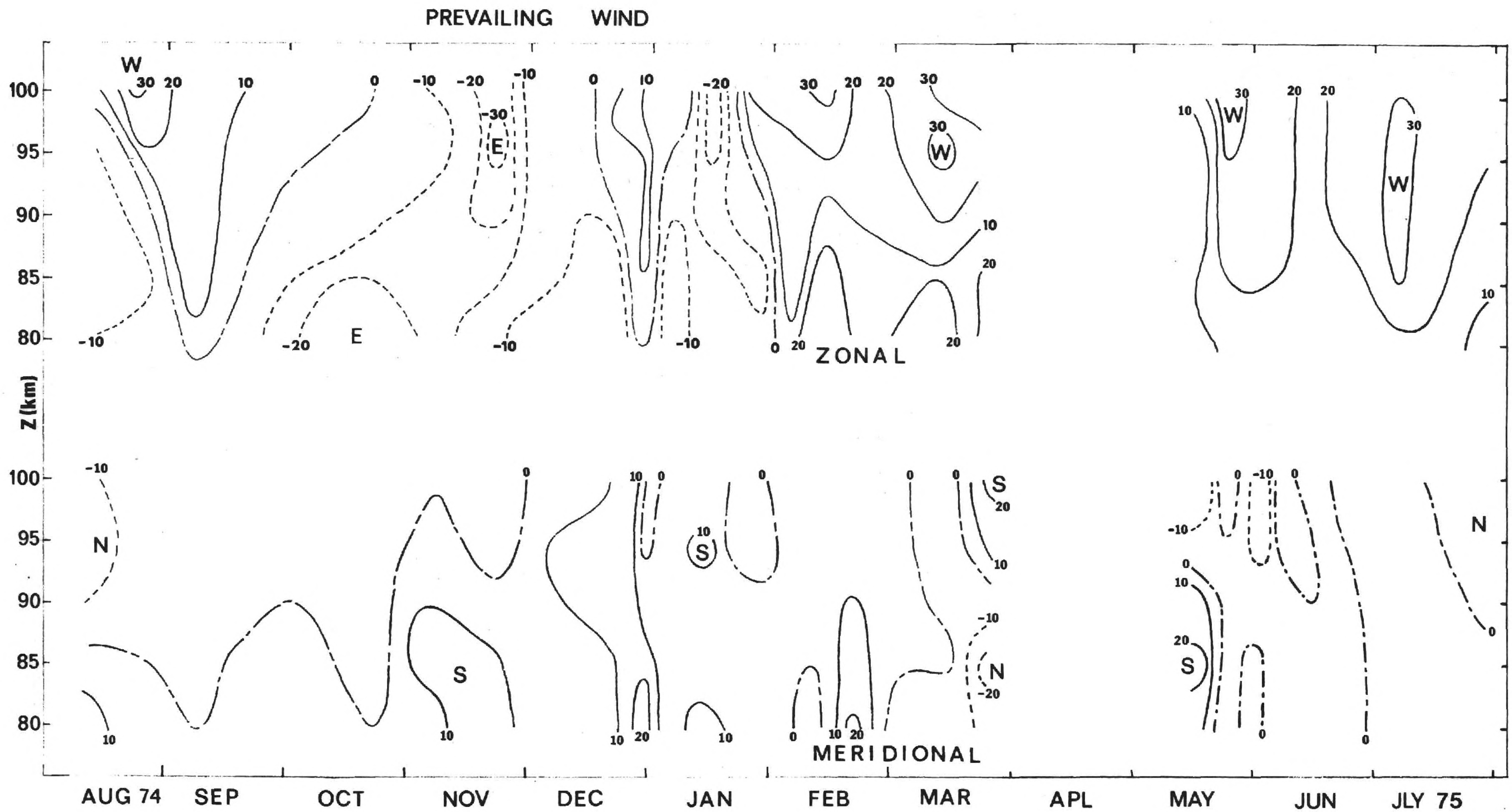
PREVAILING WIND
ZONAL
MERIDIONAL
Z (km)
100
95
90
85
80
AUG 74
SEP
OCT
NOV
DEC
JAN
FEB
MAR
APL
MAY
JUN
JLY 75

Figure 1.

48 HOUR COMPONENT

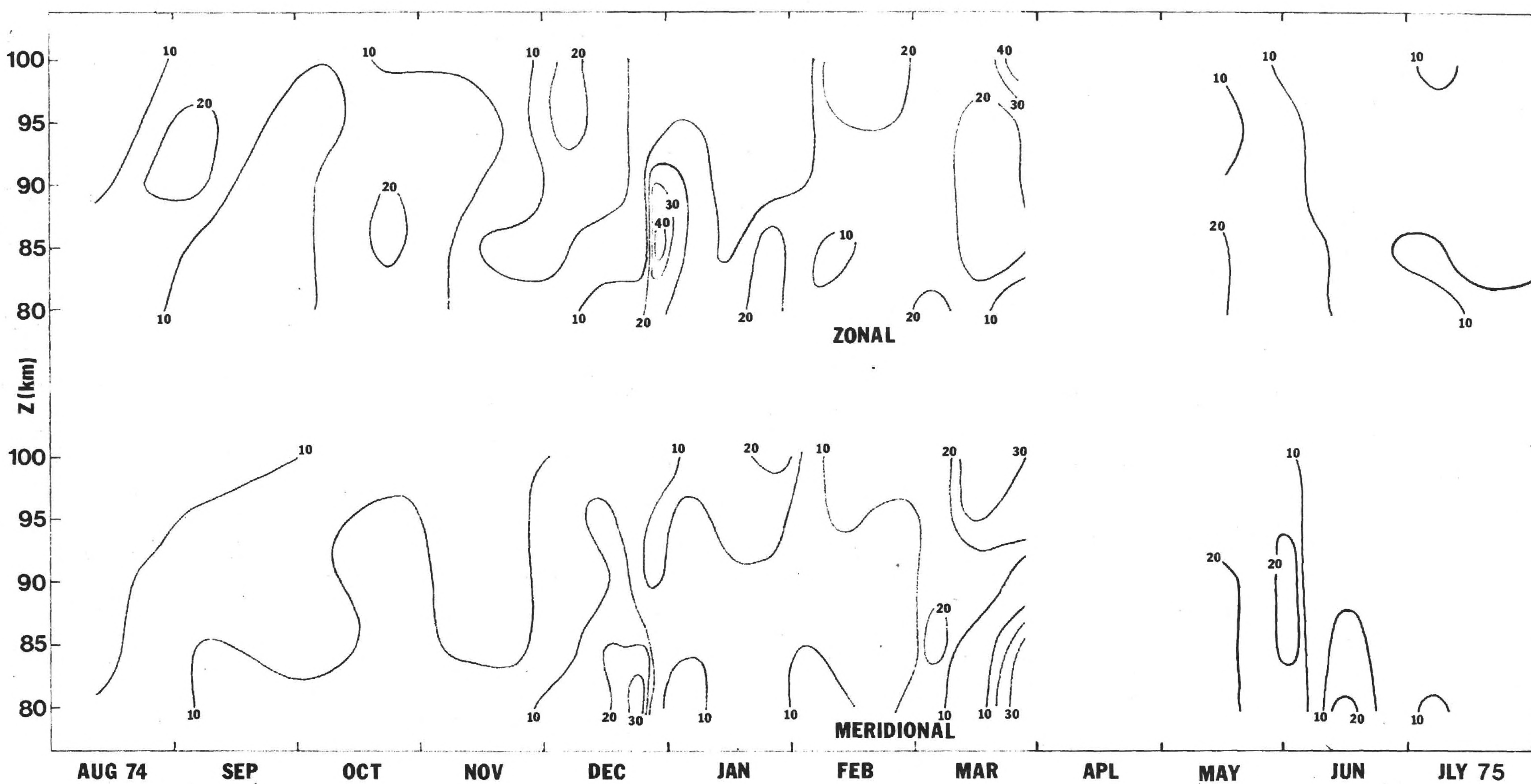

Figure 2.

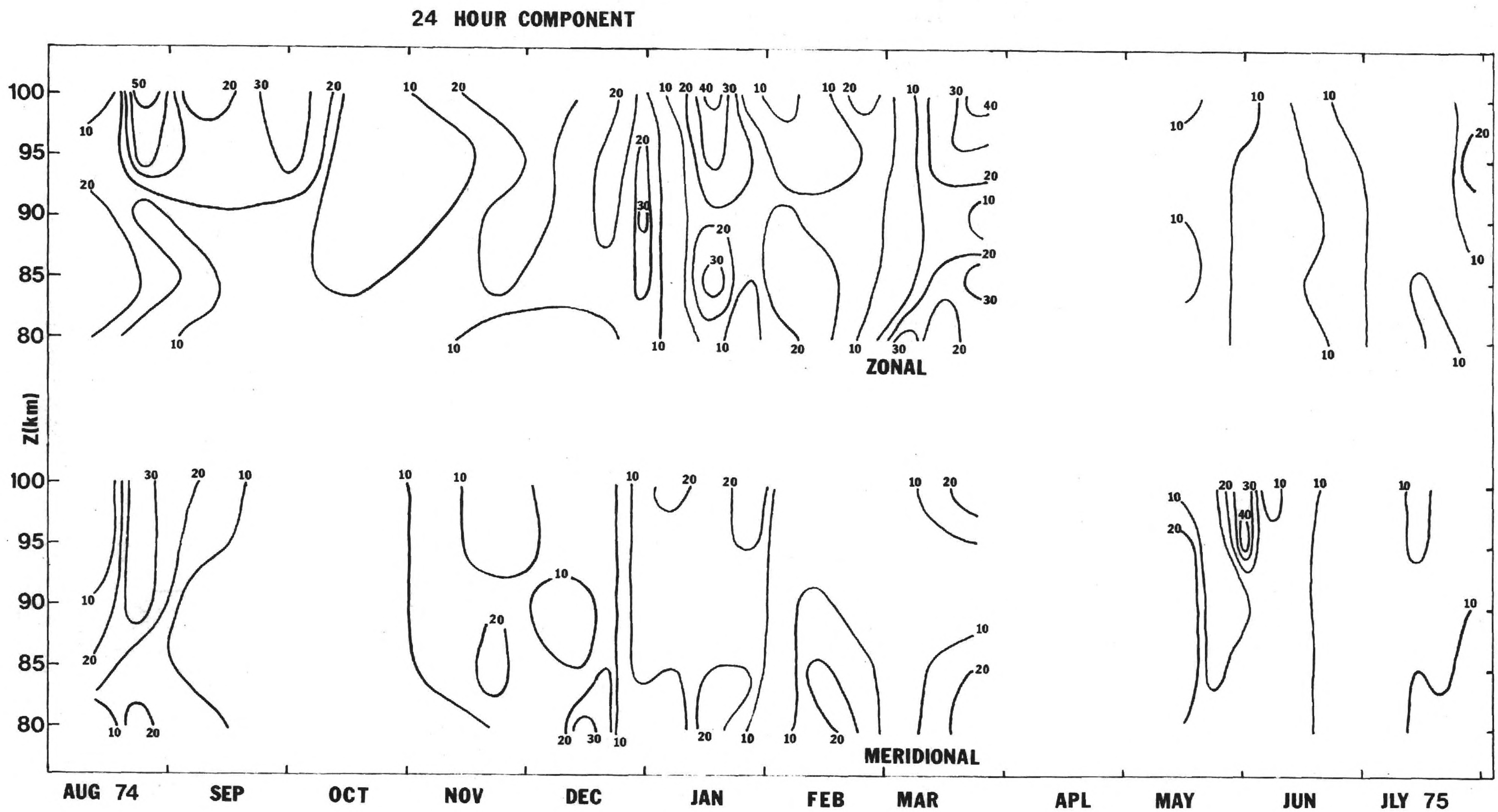
24 HOUR COMPONENT
ZONAL
MERIDIONAL
Z(km)
100
95
90
85
80
AUG 74
SEP
OCT
NOV
DEC
JAN
FEB
MAR
APL
MAY
JUN
JLY 75

Figure 3.

12 HOUR COMPONENT

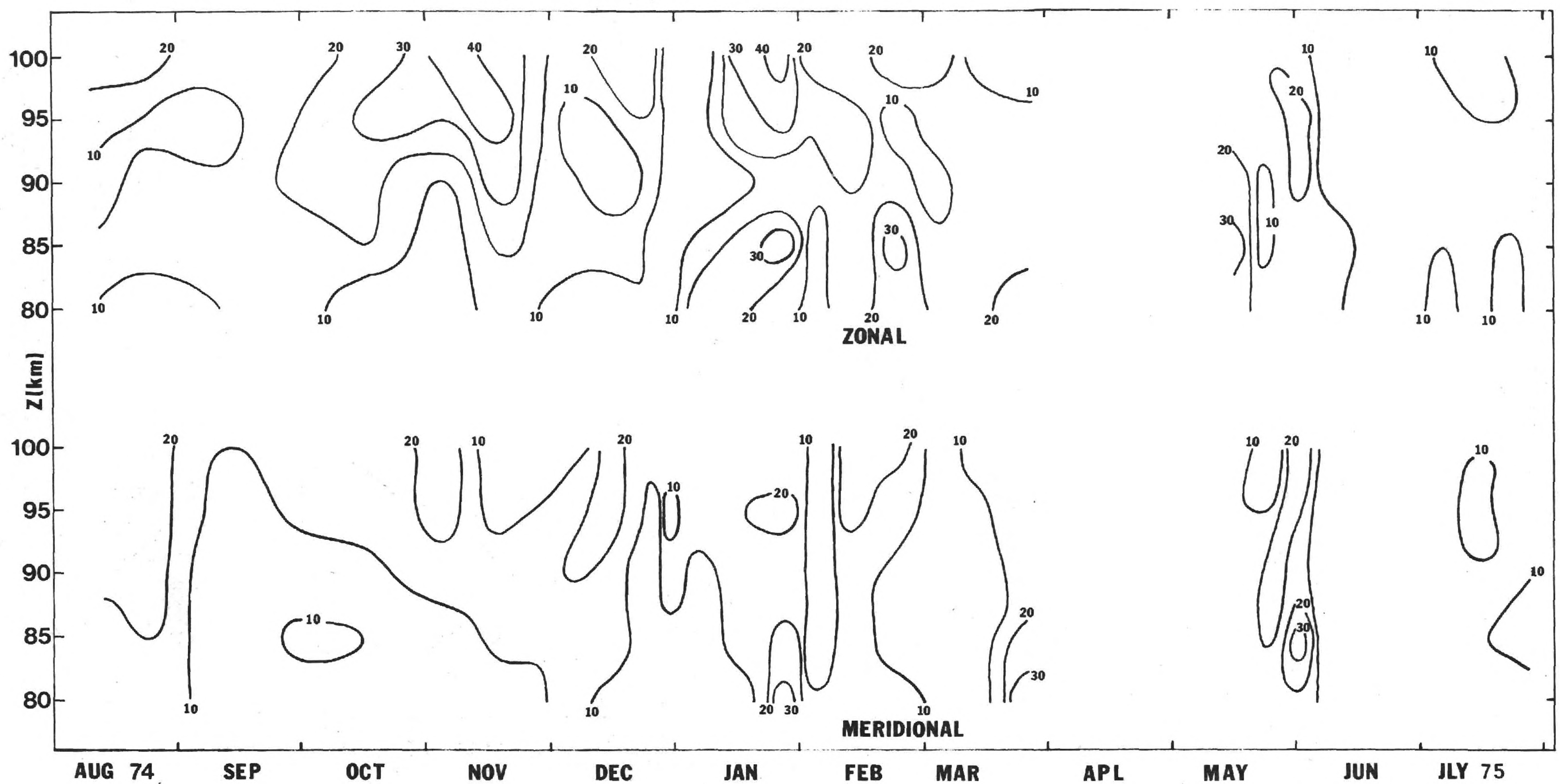

Figure 4.